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Robert T. Jackson

Memoirs of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. XXXVI. No. 1.

IX /

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE
TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE
U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM AUGUST,
1899, TO MARCH, 1900, COMMANDER JEFFERSON F. MOSER, U. S. N.,
COMMANDING.

XI.

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THE GENUS COLOBOCENTROTUS.

HARVARD
UNIVERSITY

By ALEXANDER AGASSIZ.

WITH FORTY-NINE PLATES.

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CAMBRIDGE, U.S.A.:

Printed for the Museum.

NOVEMBER, 1908.

TROPICAL PACIFIC.

The following Publications of the Museum contain Reports on the Dredging Operations in charge of Alexander Agassiz, of the U. S. Fish Commission Steamer "Albatross," during 1899 and 1900, Commander Jefferson F. Moser, U. S. N., Commanding.

- I. A. AGASSIZ. Preliminary Report and List of Stations. With Remarks on the Deep-Sea Deposits by Sir John Murray. Mem. M. C. Z., Vol. XXVI. No. 1. January, 1902. 114 pp. 21 Charts.
- II. A. G. MAYER. Some Species of Partula from Tahiti. A Study in Variation. Mem. M. C. Z., Vol. XXVI. No. 2. January, 1902. 21 pp. 1 Plate.
- III. A. AGASSIZ and A. G. MAYER. Medusæ. Mem. M. C. Z., Vol. XXVI. No. 3. January, 1902. 40 pp. 13 Plates, 1 Chart.
- IV. A. AGASSIZ. The Coral Reefs of the Tropical Pacific. Mem. M. C. Z., Vol. XXVIII. February, 1903. 33, 410 pp. 238 Plates.
- V. C. R. EASTMAN. Sharks' Teeth and Cetacean Bones from the Red Clay of the Tropical Pacific. Mem. M. C. Z., Vol. XXVI. No. 4. June, 1903. 14 pp. 3 Plates.
- VI. W. E. HOYLE. Cephalopoda. Bull. M. C. Z., Vol. XLIII. No. 1. March, 1904. 71 pp. 12 Plates.
- VII. H. LUDWIG. Asteroidea. Mem. M. C. Z., Vol. XXXII. July, 1905. 12, 292 pp. 35 Plates, 1 Chart.
- VIII. W. E. RITTER and EDITH S. BYXBEE. The Pelagic Tunicata. Mem. M. C. Z., Vol. XXVI. No. 5. August, 1905. 20 pp. 2 Plates.
- IX. MARY J. RATHBUN. The Brachyura. Mem. M. C. Z., Vol. XXXV. No. 2. August, 1907. 54 pp. 9 Plates.
- X. C. H. GILBERT. The Lantern Fishes. Mem. M. C. Z., Vol. XXVI. No. 6. July, 1908. 23 pp. 6 Plates.
- XI. A. AGASSIZ. Echini: The Genus Colobocentrotus. Mem. M. C. Z., Vol. XXXV¹¹. No. 1. November, 1908. 8, 33 pp. 49 Plates.

IX /

Memoirs of the Museum of Comparative Zoölogy

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THE GENUS COLOBOCENTROTUS.

By ALEXANDER AGASSIZ.

WITH FORTY-NINE PLATES.

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BUREAU OF FISHERIES

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NOTE.

A small number of sea-urchins were collected during the Tropical Pacific Expedition of the "Albatross" (1899-1900), so that only a few genera and species characteristic of the Pacific will be described in succession whenever sufficient new and interesting or important material has been obtained.

The genus *Colobocentrotus* of Brandt remarkable for its peculiar primary radioles forms the subject of the first part of the Tropical Pacific Echini. This will be followed by a paper on the allied genus *Heterocentrotus*.

I have to thank Mr. Richard Rathburn of the Smithsonian for having sent me for study the types of *Colobocentrotus* collected at the Bonin Islands, by Dr. Wm. Stimpson, the naturalist of the North Pacific Exploring Expedition under command of Captains Ringgold and Rodgers.

I am greatly indebted to Mr. Magnus Westergren for the interest he has taken in the preparation of the Plates illustrating this Memoir. His accuracy in drawing, his knowledge of the structure of sea-urchins obtained during his long training in the preparation of plates on Echinoderms, is shown on every plate due to his facile pencil.

In addition to the material of *Colobocentrotus* collected by the "Albatross" during the Tropical Pacific Expedition I have availed myself of material collected by the "Albatross" at the Hawaiian Islands and in other parts of the Pacific and in the Indian Ocean, found in the collections of the Museum of Comparative Zoölogy.

ALEXANDER AGASSIZ.

NEWPORT, R. I., August 29, 1908.

TROPICAL PACIFIC ECHINI.

THE GENUS COLOBOCENTROTUS.

COLOBOCENTROTUS Brandt (A. Ag. emend.).

Colobocentrotus Brandt, 1835, Prod. p. 66.

Colobocentrotus A. Ag. Rev. Echini, p. 423 (partim).

This genus is now limited to such species as *Colobocentrotus Mertensii* Brandt and *Colob. Stimpsoni* A. Ag., the better known species, *C. atratus* and *C. pedifer*, having been separated from it and united in the genus *Podophora* Agass.

The following are the species of *Colobocentrotus* and of *Podophora* described in this memoir:

Colobocentrotus Mertensii Brandt.

Colobocentrotus Mertensii Brandt, 1835, Prod., p. 66.

Colobocentrotus Mertensii A. Ag. (partim) Rev. Echini, 1872, p. 103, Pl. III^d, figs. 4, 5, p. 426. Bonin Islands.

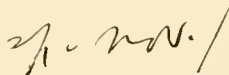
Colobocentrotus Leskei A. Ag. 1863. Proc. Phila. Acad. p. 354 is a slip of the pen for *Colobocentrotus Mertensii* Brandt.

Colobocentrotus quadriseriatus Troseh., noted by Troschel as occurring in Australia, is, I should say from his description, *Colob. Mertensii* Brandt.

This species was collected by Dr. Wm. Stimpson at Port Lloyd, Bonin Islands, North Pacific Exploring Expedition, under Captains Ringgold and Rodgers. It is figured in the Revision of the Echini, Plate III^d, figs. 4, 5.

Stimpson says it is found "in surf-washed rocks."

Colobocentrotus Stimpsoni A. Ag.



Is the large grayish pink species collected by Dr. Stimpson at the Bonin Islands, North Pacific Exploring Expedition, and described later on.

The species of *Colobocentrotus* have thus far only been collected at the Bonin Islands and, according to Troschel, in Australia.

PODOPHORA Agass.**Podophora** Agass. 1840, Cat. Syst. Ectyp., p. 19.

In 1840 Agassiz was not aware of the existence of Brandt's *Prodromus* where the genus *Colobocentrotus* was established.

Podophora atrata Agass.*Echinus atratus* Lin. 1758, Syst. Nat. ed. X., p. 655.

o/ *Echinometra atrata* Blainv., 1834, Actinol., p. 225, Pl. 20, figs. 1, 1a. *Diā. Sci. Nat.*, vol. 60, p. 206!

Podophora atrata Agass. 1840, Cat. Syst. Ectyp., p. 19.*Colobocentrotus atratus* A. Ag. (partim), 1872, Rev. Echini, p. 102, Pl. III^d, fig. 3.*Colobocentrotus atratus* Möbius, 1908, Aesthetik d. Thierwelt, fig. 5, p. 20.

Lovén in his *Echin. of Lin.* says that the type of Linnæus was collected at Mauritius, or rather that the original of the figure in the French edition of Klein to which Linnæus refers in his twelfth edition came from Mauritius. Leske's figure, to which Blainville and others refer as the typical *atratus*, has the longer marginal spines rounded at the tip. Blainville further states that it is "d'un blanc violet presque noir," which agrees with the coloring of the specimens from the Hawaiian Islands and Mauritius in the Museum collections.

Hawaiian Islands, M. C. Z. collections.

Hilo, Hawaii, Smithsonian (Albatross coll.).

Mauritius, Seychelles, Zanzibar, M. C. Z. collections. This species has also been noted as occurring at Java and the Moluccas.¹

Möbius has given an excellent figure of *Podophora atrata* from Mauritius, the dark violet species with long spines rounded at the tip. *Echinometra Quoyi* Blainv. is only the young of *P. atrata*. *Colob. Leskei* Br. is probably *P. atrata*.

Podophora pedifera Agass.*Echinus pedifer* Blainv. 1825, Dict. Sc. Nat. O., Vol. 37, p. 97. Mers Australes.**Podophora pedifera** Agass., 1846, C. Rais. Ann. Sc. Nat. VI, p. 370.**Podophora atrata** A. Ag. (partim), 1872, Rev. Ech. p. 102, Pl. III^d, fig. 3, p. 424.

The excellent description of Blainville, with his statement "couleur générale d'un vert bleuâtre, les mammelons verts, les épines livides," leaves no doubt of its identity with the greenish-olive specimens collected at Fakarava

¹ See Rev. Echini, 1872, p. 103.

by the "Albatross" Tropical Pacific Expedition 1899-1900, on the seafloor of the reef exposed to the full force of the surf.

A specimen from Chili is figured in the Revision of the Echini (Pl. III^d, fig. 3). There are also specimens of this species in the Museum collections labelled Valparaiso?, Callao, Chili, and Peru.

COLOBOCENTROTUS AND PODOPHORA.

The genus *Colobocentrotus* was established by Brandt in 1835; he also included in it *Podophora atrata* Agass., for which Agassiz in 1840 established the genus *Podophora*. With the material at my disposal I have come to the conclusion that the original *Colobocentrotus* of Brandt may be dismembered into two genera, — the one (*Podophora* Agass.) to include *P. atrata* and *P. pedifera* (Pls. 7; 20); the other (*Colobocentrotus* Brandt) limited to *Colob. Mertensii* and *Colob. Stimpsoni*, the former of which was the first species for which Brandt originally established the genus (Plates 33; 34; 37; 38; and 35; 36).

The species of *Colobocentrotus* (Plates 33, fig. 3; 34, fig. 3; 35, fig. 3; 36, fig. 3) are much flatter than those of *Podophora*. They are at once distinguished by the elongated coronal plates which carry a larger number of primary tubercles uniform in size (arranged in two horizontal rows) in both the ambulacral and interambulacral zones than in the species of *Podophora*. There are as many as twelve vertical rows of interambulacral tubercles immediately above the ambitus in *Colob. Stimpsoni* in a specimen of 65 mm. in diameter; in a specimen of *Podophora pedifera* of 55 mm. there are eight, and in a specimen of *Podophora atrata* of 45 mm. there are only six vertical rows at the ambitus.

The outline of the test of the species of *Colobocentrotus* is elliptical or circular, while it is pentagonal in *Podophora*. The general shape of the test of the species of *Colobocentrotus* and *Podophora* seems to be fairly constant. An outline of the ambitus of each of the four species (see figs. a-d p. 5), with their measurement and number of pores in the ambulacral plates on the abactinal side, is given for comparison.

Podophora pedifera Agass.

Length, denuded, 55 mm.

Width, denuded, ~~36~~ mm.

Height, denuded, 30 mm.

47/

Pairs of pores in each ambulacral plate 11, 12, near the ambitus on the abactinal side.

Podophora atrata Agass.

Length, denuded, 45 mm.

Width, denuded, 38 mm.

Height, denuded, 18 mm.

Pairs of pores in each ambulacral plate 9, 10, near the ambitus on the abactinal side.

Colobocentrotus Stimpsoni A. Ag.

Length, denuded, 64 mm.

Width, denuded, 53 mm.

Height, denuded, 24 mm.

Pairs of pores in each ambulacral plate 7, 8, near the ambitus on the abactinal side.

Colobocentrotus Mertensii Brandt.

Length, denuded, 54 mm.

Width, denuded, 48 mm.

Height, denuded, 22 mm.

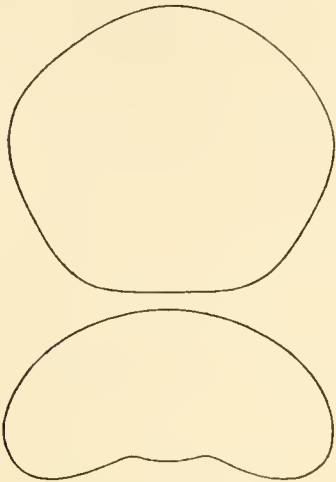
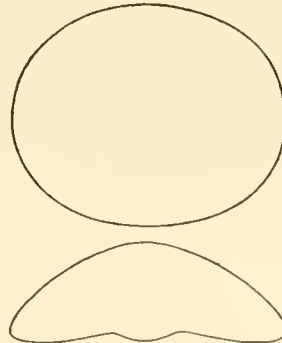
Pairs of pores in each ambulacral plate 7, 8, near the ambitus on the abactinal side.

The outline at the ambitus of *Podophora pedifera* (Fig. *a*; Pl. 13, fig. 1) and of *Podophora atrata* (Fig. *b*; Pl. 25, fig. 5) is pentagonal in both; the actinal side of *Podophora pedifera* is strongly arched, while that of *Podophora atrata* is nearly flat. The ambitus of *Colob. Stimpsoni* is ellipsoidal (fig. *d*), in *Colob. Mertensii* it is almost circular (fig. *c*). This dissimilarity can scarcely be due to age, as the difference in length of the two specimens is only 10 mm. The number of tubercles in *Colob. Mertensii* is less than in *Colob. Stimpsoni*. In *Mertensii* those in the interambulacrum at the ambitus, on the actinal side, are somewhat larger; hence that side is more concave.

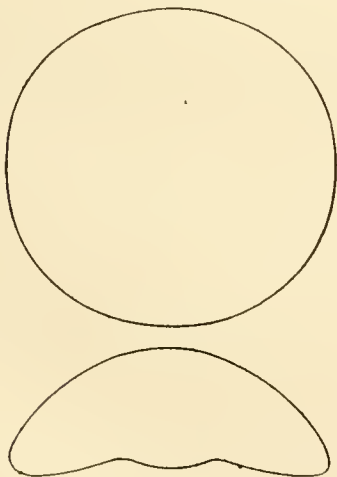
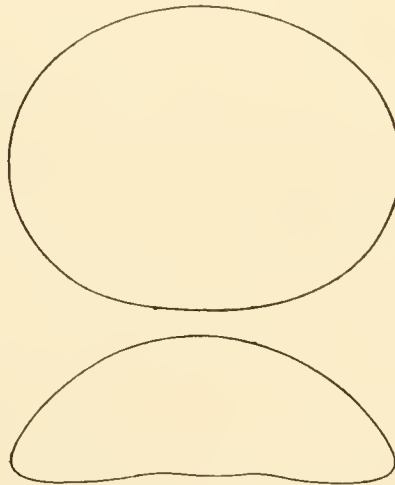
Photography is often misleading when reproducing specimens of natural size, some parts are apt to be somewhat out of focus. The profiles in Plates 8, fig. 3; 20, fig. 6; 34, fig. 3; and 36, fig. 3, do not fully correspond to the diagrams (figs. *a-d*) which are correct.

A comparison of the odd anterior ambulacrum of the two species of *Podophora* (Pl. 46, figs. 1, 5), and of *Colobocentrotus Stimpsoni* (Pl. 46, fig. 9) brings out strikingly their specific differences. In a specimen of *Podophora pedifera* Agass. of 55 mm. in diameter the ambitus crosses the fifth and sixth

plate, and the greatest width of the poriferous field is at the second and third plate from the actinostome, leaving a comparatively narrow interambulacral field (Pl. 12, fig. 1). From the ambitus to the abactinal system the large tubercles

FIG. a. *P. pedifera*.FIG. b. *P. atrata*.

occupy the whole of the ambulacral plate, leaving room only for a thin line of small miliaries. The abactinal tubercles alone have a circular scrobicular area; from the fourth plate from the apex it becomes irregular in outline,

FIG. c. *Colob. Mertensii*.FIG. d. *Colob. Stimpsoni*.

and the pairs of pores are sometimes pushed in two arcs, or forced out towards the outer edge of the ambulacral plate. At the ambitus and on the actinal side the primary tubercles form two short rows on each side of the primary rows and then extend towards the actinostome as a single row of small secondaries

with a few miliaries on each side of the median line separating the two poriferous fields. The difference in appearance of the pores of the actinal edge of the poriferous field of the region at the ambitus and those of the abactinal side of the ambulacral system is shown on Pl. 46, figs. 2, 3, 4.

The odd anterior ambulacrum of a specimen of *Podophora atrata* measuring 46 mm. in diameter is at once distinguished from that of *Podophora pedifera* by the more regular outline of the vertical rows of primary tubercles. Both the mammary boss and scrobicular area are circular in outline (Pl. 46, fig. 5); they occupy a smaller arc of the ambulacral plates, having a larger space free from miliaries along the median line of the ambulacral zone. There are here and there a few small secondary tubercles in the inner angles of the ambulacral plates.

The vertical rows of primary tubercles extend as small tubercles to the edge of the actinal system, and numerous minute secondaries and miliaries are intercalated between the pairs of pores of the poriferous field. This is comparatively narrower than that of *Podophora pedifera*, leaving a much broader actinal interambulacral zone to separate the poriferous fields of adjoining ambulacra (Pl. 24, fig. 1) than in *Podophora pedifera*. The change in the pairs of pores as we pass from the actinal edge to the ambitus and to one of the abactinal pairs of pores are seen in Pl. 46, figs. 6, 7, 8.

In a specimen of *Colobocentrotus Stimpsoni* measuring 65 mm. in longest diameter the primary tubercles above the ambitus are of nearly the same size with a circular mammary boss and scrobicular area (Pl. 46, fig. 9), those at the ambitus being slightly larger and those on the actinal side of the ambitus decidedly larger. In these the mammary boss and the scrobicular area are somewhat elliptical. The abactinal primary tubercles form above the ambitus four slightly undulating vertical rows with small miliaries on both sides of the median line and miliaries between the outer and inner vertical rows. Below the ambitus there are four irregularly placed large primary tubercles with a somewhat smaller one, and below that two vertical rows of small, distant secondaries on each side of the median line extending to the actinal system, with numerous miliaries and minute secondaries filling the spaces between the pairs of pores of the poriferous field.

On the abactinal side of the test there are usually three large tubercles on each plate; near the abactinal system they are reduced to two or to one with a small secondary. The poriferous arcs occupy the outer part of the ambulacral plates. There are eight pairs of pores arranged in a very open

horse-shoe shape and at the ambitus they are beginning to be crowded out of place to form the actinal poriferous field. Pl. 46, fig. 10 is a pair of pores from the poriferous field, fig. 11 a pair of pores at the ambitus, and fig. 12 one of the pores of the ~~twelfth~~ ambulacral plate, counting from the actinal system.

eleven /

COLOBOCENTROTUS Brandt (A. Ag. emend.)

Colobocentrotus Mertensii, Brandt.

Pls. 2, figs. 8-13; 3^a, figs. 9-11; 30; 32, figs. 5-8; 35; 36; 39,
figs. ~~34~~; 44; 45, figs. 6-10.

1-2 /

Colobocentrotus Mertensii differs from *Colob. Stimpsoni* in having a more circular outline (Pl. 36, figs. 1, 2) and being less depressed (Pl. 36, fig. 3). It has a proportionally larger actinal system (Pl. 36, fig. 1). The actinal surface is more sunken than that of *Colob. Stimpsoni*. The ambital edge both of the ambulacral and interambulacral zones carries much larger primary tubercles (Pl. 36, figs. 1, 3) than those of *Colob. Stimpsoni*. The actinal lips are broad; the actinal plates of the interambulacral areas are narrower than those of *Colob. Stimpsoni*. The actinal interambulacral zone carries four irregular, vertical rows of most distinct small secondaries larger than in the corresponding zones of *Colob. Stimpsoni*.

The poriferous fields are broad, slightly sunken; the median line of the small distant ambulacral primaries consists of two vertical rows also larger than those of *Colob. Stimpsoni*. The poriferous field is studded with minute miliaries and small secondaries.

The arrangement of the miliaries on the buccal plates and of the cluster of narrow crescent-shaped plates of the actinal system (Pl. 36, fig. 1), does not differ materially from that of *Colob. Stimpsoni* (Pl. 38, fig. 1). The five pairs of poriferous buccal plates are somewhat larger in *Colob. Stimpsoni* than in *Colob. Mertensii*. At the ambitus there are two rows of eight large primary interambulacral tubercles. These rapidly taper to four rows of small tubercles towards the actinal system; on the abactinal side the primary interambulacral tubercles diminish gradually to the second or third plate from the ambitus and then remain of nearly uniform size, diminishing most gradually towards the abactinal system. At the fourth plate from the apex there are but six primary tubercles to each interambulacral plate, arranged in two horizontal rows; while nearer the ambitus there are eight or ten similarly arranged. The intertubercular space is filled with miliaries (Pl. 36, figs. 2, 3).

In the ambulacral zone there are four vertical rows of large primary tubercles at the ambitus. These gradually diminish in size towards the abactinal system. On each ambulacral plate there are three primary tubercles, two, one above the other, along the median ambulacral line, the other on the distal side of the plate, surrounded by the poriferous arc. This consists of seven pairs of pores, while there are eight in *Colob. Stimpsoni*. The intertubercular space is filled with miliaries.

The abactinal system is more raised than in *Colob. Stimpsoni*, and it is covered by a coarser tuberculation of small secondaries (Pl. 36, fig. 2). The anal system is deeply sunken; the genital pores are slightly larger than those of *Colob. Stimpsoni*. There are from ten to twelve closely packed tubercles on the genital plates, and three on the ocular plates. The madreporic body occupies the two sides of the distal part of the right anterior genital; the proximal part adjoining the anal system carries a few small secondaries and miliaries.

Colobocentrotus Mertensii, when covered with spines (Pl. 35) is of a darker ash color than *Colob. Stimpsoni*. The actinal spines of the former, corresponding to the longer small primary tubercles of that region, are longer and larger (Pl. 35, fig. 1) than those of *Colob. Stimpsoni* (Pl. 33, fig. 1), and the large, flat, truncated radioles are more numerous at the ambitus than in *Colob. Stimpsoni*.

5 / 2-3 /

In *Colob. Mertensii*, the primary radioles of the abactinal side of the test are larger than those of *Colob. Stimpsoni* (compare Pl. 35, figs. 2, 3 with Pl. 33, fig. 2) and are also more distant, giving a freer circulation of water round the spines to the miliaries and pedicellariæ of the intertubercular areas. The small radioles covering the abactinal system (Pl. 35, fig. 2) are more pointed than those of the abactinal system of *Colob. Stimpsoni* (Pl. 33, fig. 2).

The order of appearance of the vertical rows of primary tubercles of *Colob. Mertensii* is shown on Pl. 39, figs. 1, 2, which represent the arrangement of the radioles (fig. 1) in the right posterior ambulacrum, with the right posterior interambulacrum and a part of the right anterior ambulacrum. Fig. 2 shows the arrangement of the radioles of the odd posterior interambulacrum, with the bivium and half of the right posterior ambulacrum.

Colobocentrotus Stimpsoni A. Ag.

27. nov. /

Pls. 2, figs. 4-7 ; 29 ; 32, figs. 1-4 ; 33 ; 34 ; 37-39, figs. ~~4-5~~ ;
40-45, figs. 1-5.

3/4/

A specimen of *Colob. Stimpsoni*, measuring 65 mm. when denuded, shows its elliptical outline (Pls. 34, figs. 1, 2 ; 38, figs. 1, 2). The abactinal system is slightly raised ; the anal system sunken ; the poriferous zone is somewhat sunken, and the genital pores are deeply sunken. The mamelon of the abactinal primary tubercles is glossy, and the general appearance of this species, when seen from above, is that it is covered with a most uniform tuberculation diminishing but slightly in size towards the apical system. Immediately at the ambitus and on both sides of it are placed the horizontal rows of the largest primary tubercles (Pls. 34, figs. 1, 3 ; 38, figs. 1, 3). A profile view (Pls. 34, fig. 3 ; 38, fig. 3) shows the nearly flat actinal side and low, subconical arched test. A view from the actinal side (Pls. 34, fig. 1 ; 38, fig. 1) shows that the actinal surface of the test is flat, the ambital edge being slightly raised. The poriferous fields are wide, extend to the ambitus, and are separated by the comparatively narrow interambulacral zone. The two median vertical rows of small ambulacral tubercles extend to the actinostome. Two still smaller additional rows of secondary tubercles run across the poriferous field about half way between the median line and the outer edge of the poriferous zone.

Seen from the interior of the test the interambulacral plates show a well marked groove in the middle of the suture of adjoining plates which is not shown in the drawings owing to the absence of shading, and the poriferous zone is raised well above the general level of the remaining part of the ambulacral plates (Pl. 42, fig. 1).

Owing to the flatness of the test of *Colob. Stimpsoni* and the sharp angle made by the ambitus between the abactinal and actinal sides the coronal plates at the ambitus are greatly compressed and the plates very narrow (see Pl. 42, fig. 1), this is also seen in the compression of one of the ambulacral ambital plates (Pl. 42, fig. 7) in which the sutures between the demi-plates carrying the pairs of pores are practically obliterated. Compare this with an abactinal plate, the tenth from the actinal system (Pl. 42, figs. 5, 6), in which (fig. 7) the sutures of the demi-plates of the eight pairs of pores are sharply defined.

In a view of the abactinal part of the ambulacral system, seen from the

interior of the test (Pl. 42, fig. 8, and Pl. 43, fig. 3), it is easy to see the structure of the upper ambulacral plates. Each plate is made up of a narrow plate reaching from the median line to the outer edge of the plate and of a larger plate into which run from the outer edge half way to the median line seven demi-plates carrying seven pairs of pores. In the tenth plate from the actinostome in which the eight pairs of pores are only slightly crowded to one side (Pl. 42, fig. 5), we see the arrangement of the three large primary tubercles and the intertubercular space occupied by the miliaries and small secondaries. A view from the inside of ~~the left posterior~~ ambulacrum shows the sutures indicating the composite structure of the ambulacral plate (Pl. 42, fig. 6). In the narrow upper plate the pores marked with a small x correspond to the upper pair of pores of Pl. 42, fig. 5, also marked with an x and on the same figure we can trace the suture of the demi-plates of the seven other pairs of pores forming the poriferous arc which extend half way from the outer edge towards the median ambulacral sutures. 2/ uu /

In an exterior view from the actinal side of the poriferous field of the odd anterior ambulacrum (Pls. 34, fig. 1; 38, fig. 1; 42, fig. 3) it is impossible to detect either the sutures of the primary plates or of the demi-plates; but in a view from the interior (Pl. 42, fig. 4) the peculiar shape assumed by the primary actinal ambulacral plates and demi-plates, owing to the crowding and compressing of the poriferous plates is shown in Plate 42, fig. 4. The pores marked with x in fig. 4 in the two ambulacral plates correspond to the pairs of pores similarly marked on Pl. 42, fig. 3. The poriferous field is marked by the number of miliaries and small secondary tubercles interspersed between the pairs of pores. (Pl. 42, fig. 3.)

The outline of one of the pairs of poriferous buccal plates of *Colob. Stimpsoni* is shown on Pl. 42, fig. 2. They each carry a few miliaries and a number of small secondaries. The plates are originally elliptical; they abut in older specimens.

Owing to the thickness of the test the passage for the tubes leading to the pedicels slants very considerably and distant pairs as seen from the interior on figs. 4, 6, Pl. 42, are thus brought closely together on the exterior side of the test figs. 3, 5, Pl. 42.

In figs. 3, 4, 5, 6, of Pl. 42, the two minute crosses indicate the position of the pairs of pores on the inner and outer faces of the test; figs. 3, 4 on the actinal part of the poriferous field of the odd anterior ambulacrum and figs. 5, 6 of a pair of pores of the abactinal part of the odd anterior ambulacrum of

Colobocentrotus Stimpsoni. These figures show how the distant openings for the pedicels slant across the thickness of the test to come together and form the pairs of pores.

On Pl. 41, fig. 1, is given a figure of the left anterior interambulacrum of a specimen of *Colob. Stimpsoni* measuring with its spines 88 mm. in diameter with 14 and 15 coronal plates. At the ambitus on the abactinal side there are 12 rows of primary tubercles which form disconnected vertical rows; at the tenth plate there are but five rows and at the third plate from the apex only three. The tubercles diminish but slightly in size from the ambitus towards the abactinal system and the intertubercular space is well filled with miliaries. Below the ambitus on the actinal side are found the largest of the primary tubercles forming two horizontal lines, the lower one of which is the largest, extending across the fifth and sixth plates from the actinal system. These tubercles carry the large flattened radioles truncated at the tip which form the ring of larger radioles round the base of the abactinal part of the test.

Between the row of large tubercles and the actinal system the interambulacral plates on each side of the poriferous field become much narrower (Pls. 41, fig. 1; 38, fig. 1; 34, fig. 1). There are only four indistinct vertical rows of small primary tubercles. The rest of the plates is filled with still smaller primary tubercles and patches of miliaries irregularly arranged.

The actinal lips are short but well marked. The lower part of fig. 1, Pl. 41, shows the distortion which takes place in the outline of the large primary tubercles below the ambitus owing to the great compression due to the formation of the sharp angle of the test at the ambitus. Fig. 3, Pl. 41, shows one of the most distorted of the primary tubercles on the fifth plate from the actinostome, the mammary boss, and the scrobicular area being pushed out of shape. Fig. 4 shows the same tubercle in profile. Fig. 2, Pl. 41, shows the more regular primary tubercles of the abactinal part of the test in which the boss and the scrobicular area are but slightly distorted, the boss and area being usually circular, Pl. 41, fig. 5. The grouping of the miliaries does not seem to follow any rule. Pl. 41, fig. 6, shows those of one of the plates near the actinostome of the right posterior ambulacrum.

In a specimen measuring 88 mm. in diameter, including the spines, it is possible to trace the twelve vertical rows of the primary radioles of the interambulacral areas. In Pl. 39, fig. 3, the dotted lines show the twelve rows of the right posterior interambulacrum and the four vertical rows of the right poste-

inter /

rior ambulacrum. On fig. 4 of the same plate are shown the corresponding vertical rows of the right anterior ambulaerum and interambulacrum. In both the interambulacra two of the vertical rows along the median line are included by the inner and outer rows and do not extend either to the abactinal or the ambital region.

The abactinal system when denuded shows that the genital plates are covered with closely packed primary tubercles only slightly smaller than those of the rest of the abactinal surface of the test above the ambitus. (Pls. 34, fig. 2; 38, fig. 2; 43, fig. 2.) There are in addition a few miliaries and small secondaries irregularly scattered between the larger tubercles.

The madreporic genital is much larger than the other genitals; the madreporite occupies the greater of the two sides of the plate. The proximal part carries two primary tubercles and from four to five smaller ones as well as a few miliaries. The genital openings are large, slightly sunken; the lateral posterior genitals are smaller than the odd posterior genital and the left anterior ones. (Pl. 43, fig. 2.)

The genital plates are heptagonal. The left anterior genital carries no less than sixteen primaries with a few miliaries and a couple of smaller primaries. (Pl. 41, fig. 7.) The other genitals carry from twelve to fourteen primaries with a few miliaries and secondaries.

The ocular plates are pentagonal, they carry three primary tubercles with two or three small miliaries, the ocular pores are very small. The posterior oculars approach the anal system nearer than the anterior pair or the odd ocular. (Pl. 43, figs. 2, 3.)

The anal system is irregularly circular and covered with three to four concentric rows of irregularly shaped pointed and elliptical plates. (Pl. 43, figs. 2, 3.)

In a specimen of *Colob. Mertensii* measuring 88 mm., when seen from above the primary radioles covering the abactinal system are seen to be somewhat smaller than those of the rest of the test (Pls. 33, fig. 2; 37, fig. 2; 43, fig. 1), with the exception of a few larger triangular and elliptical ones which bridge over the anal system (Pls. 40, figs. 30-32; 43, fig. 1).

On Plates 33 and 37 are given views of a specimen of *Colob. Mertensii*, measuring 88 mm. in diameter. The ambital fringe of large truncated flattened primary spines carried by the larger tubercles on the actinal side of the ambitus and at the ambitus resemble slightly those of *Podophora atrata*; they are comparatively shorter and narrower (Pls. 33, figs. 1, 2; 37, figs. 1, 2)

Simpson /

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than those of that species (Pls. ²⁰~~33~~, figs. ⁵~~1-3~~; ⁽²¹⁶⁾~~37~~, figs. 1-3). The primaries of the abactinal side of the test are much smaller than those of *Podophora* and are loosely packed upon the test, leaving considerable open space round each tubercle. This open space is specially marked on the line separating the ambulacral from the interambulacral zones (Pls. ~~33~~, figs. 2, 3; ~~37~~, figs. 2, 3). The general color of the radioles is of a grayish pink color with a slight tinge of green on the upper surface of the larger primary ambital radioles.

Seen in profile and from the abactinal side the primary radioles which are irregularly circular at the tip are seen to diminish very gradually in size above the ambitus as they reach towards the apical system (Pls. ~~33~~, figs. 2, 3; ~~37~~, figs. 2, 3). The large abactinal radioles immediately above the ambitus are arranged more closely than those more distant from it (Pls. ~~33~~, fig. 3; ~~37~~, fig. 3).

Seen from the actinal side (Pls. ~~33~~, fig. 1; ~~37~~, fig. 1), the actinal membrane is nearly bare, carrying but few small clusters of miliary spines on the pairs of poriferous plates and a few minute spines irregularly scattered over it. (Pls. ~~33~~, fig. 1; ~~37~~, fig. 1). The actinal side of the test below the ambitus is covered with slender somewhat club-shaped spines varying but slightly in shape or size between the actinal system and the actinal side of the ambitus. The poriferous fields are separated by wide interambulacral zones (Pls. ~~33~~, fig. 1; ~~37~~, fig. 1).

The spines of the actinal system close to the teeth are short, club-shaped, slightly flattened (Pl. 40, fig. 1); those from the buccal membrane are somewhat longer (Pl. 40, fig. 2). Half way between the actinal system and the ambitus the radioles are much stouter and only slightly club-shaped (Pl. 40, figs. 3, 4), as are the smaller spines found on the smaller secondary granules or larger miliaries (Pl. 40, fig. 5); these spines are all delicately striated with an ill-defined milled ring.

Below the ambitus we pass suddenly to much larger flattened, angular radioles, rounded at the tip, with a large base for the muscular attachment (Pl. 40, figs. 6-8). These spines form a part of the principal subambital fringe of radioles, the primary radioles of which are figured on Pl. 40, figs. 9-11; these radioles resemble those of *P. pedifera*, but are comparatively shorter and narrower; they are flat on the lower surface, somewhat spathiform on the upper surface, and greatly flattened towards the tip of the radiole, as is shown by a profile view (Pl. 40, figs. 9, 11).

We now come to the larger spines of the abactinal pavement immediately

above the ambitus; they are highly asymmetric, fan-shaped, and polygonal (Pl. 40, figs. 12-14); somewhat more abactinally from the ambitus the polygonal radioles are smaller (Pl. 40, figs. 15-17); midway between the ambitus and the abactinal system the primary radioles of the odd ambulacrum are slightly smaller than those nearer the ambitus (compare Pl. 40, figs. 18-20, to Pl. 40, figs. 21-23); nearer the abactinal system the radioles have become still smaller (Pl. 40, figs. 24, 25; and Pl. 40, figs. 26, 27). Pl. 40, fig. 28, is one of the miliary spines from the upper extremity of the right posterior interambulacrum, hidden by the larger primary radioles. Figures of some of the primary radioles of the anal system are given on Pl. 40, figs. 29-32.

Seen from the interior, there is a small triangular plate between the actinal plates of the odd posterior interambulacrum (Pl. 43, fig. 7) and of the right anterior interambulacrum, which may be the remnant of the primordial plates of these interambulacra. 6/t/

PODOPHORA Agass.

Podophora atrata Agass.

Pls. 2, figs. 1-3; 3^a, figs. 5-8; 16, figs. 9-14; 17-28; 31, figs. 5-8.

A fine specimen of *Podophora atrata*, measuring 97 mm. including the spines, is figured on Pl. 21^b. It was collected, with others, by the Hon. Nicolas Pike, at Mauritius. When seen from above, it is of a dark violet, almost black; seen from the actinal side the marginal spines are of a light violet color towards the tip, passing to a very light shade of the same color. The smaller flattened and elongated actinal spines, as well as the miliary spines of the buccal plates, are of the latter shade; the actinal membrane is chocolate brown. The larger marginal spines are of a somewhat lighter color on the upper side, with a tinge of green; the upper surface is also coarsely and irregularly granular and pitted. On the lower side they are smooth or only slightly pitted near the tip.

A very interesting specimen of *Podophora atrata* from Mauritius is figured on Plate 21^a, figs. 1-3. It is marked for the abnormal development of a number of the ambital radioles. Instead of being merely cylindrical as is the case in the large majority of the specimens examined they are club-shaped and proportionally larger than the ambital radioles usually are. Their shape reminds one somewhat of the club-shaped spines of *Cidaris Blumenbachii*.

The actinal system of *Podophora atrata* is pentagonal (Pls. 20, fig. 2; 21, fig. 1). The lips of the gill cuts are short, sharply marked; the proportion of the actinostome to the test is as 23 to 38. There are five pairs of small rectangular poriferous plates. The buccal membrane is only covered by a few round or elliptical plates irregularly scattered and with five clusters of narrow crescent-shaped plates placed distally next to the pairs of poriferous plates.

In a smaller specimen (Pl. 25, fig. 2) the poriferous buccal plates form a nearly closed ring, the elongated buccal plates are less closely packed than in older specimens, and the isolated circular plates are more distant.

The changes which take place in the interambulacral zones during the growth of the test are shown on Pl. 24, figs. 1-4, giving the left anterior interambulacrum of specimens measuring 8, 14, 26, and 45 mm. in diameter. In fig. 1, the same as Pl. 25, figs. 1-5, there are six and seven interambulacral plates, each carrying a large or small primary tubercle, with a number of miliaries or small secondaries along the median line and the outer edge of the plates.

On Pl. 24, fig. 2, a specimen measuring 14 mm. in diameter, there are eight and nine interambulacral plates, and a second vertical row of primary tubercles is forming along the median line of the fourth and fifth plates, as well as another vertical row of small secondaries on the outer edges of the third, fourth, fifth, sixth, and the second, third, fourth, fifth plates counting from the actinostome.

On Pl. 24, fig. 1, these two outer vertical and median rows can be detected by the greater size of the small secondary on each side of the two primary rows in the position of the new vertical rows well developed in fig. 2. In the next stage of the same interambulacrum figured, a specimen measuring 26 mm. in diameter (Pl. 24, fig. 3) with eleven and eleven plates, the four vertical rows of primary tubercles are well developed. The first rows, so prominent in figs. 1, 2, are still readily distinguished from the two inner and the two outer rows by the greater size of the primary tubercles, which extend from the second to the seventh plate, while the two inner rows extend the one from the fourth to the eighth plate, the other from the fifth to the eighth plate.

In the specimen, figured on Pl. 24, fig. 2, the miliaries are proportionally much more numerous than in the younger specimen (Pl. 24, fig. 1); they are quite crowded in the next stage (Pl. 24, fig. 3), and in the older specimen, 45 mm. in diameter, they are somewhat more openly arranged (Pl. 24, fig. 4).

In this specimen there are twelve and twelve plates; the outer vertical rows extend from the second to the ninth and perhaps to the tenth plate, the inner median rows from the fourth to the ninth plate. There still exists a marked difference in the size of the primaries of the first vertical rows near and at the ambitus compared to the primary tubercles of the other rows, which, with the exception of the upper tubercles, are nearly of the same size. It will be noticed that the outline of the scrobicular areas and of the mammary boss varies greatly; they are circular, angular, or elliptical according to their position in the plate and the amount of space available (see Pl. 24, figs. 5, 7, 8). These changes are due to the great pressure brought about, especially at the ambitus, by the sudden change of direction in the plates passing from the abactinal side to the ambitus and to the actinal surface. It will be seen that in the large specimen (Pl. 24, fig. 4) there are on the actinal side four vertical rows of small secondary tubercles separating the adjoining interambulacral rows (Pl. 24, fig. 4).

The order of appearance of the tubercles of the vertical rows can be equally well traced in specimens covered with radioles. On Pl. 25, fig. 1, is seen a young specimen 14 mm. in diameter with the spines having but two vertical rows of large primary tubercles, as in Pl. 24, fig. 1, and Pl. 25, figs. 3, 4. Pl. 25, fig. 1, shows the pavement of radioles of the five ambulacral and interambulacral zones, each with two rows of primary radioles and the pavement covering the abactinal system. This is shown more in detail on Pl. 22, fig. 1. In fig. 2 of the same plate, in a somewhat larger individual, we can see the first trace of the spines of the inner vertical row of tubercles. This is somewhat more advanced in the next largest specimen figured, Pl. 22, fig. 3. In a specimen of 26 mm. the small radioles of two of the plates of the outer rows can be distinguished; those of the inner median rows are well seen. In the next stage these radioles have all become larger and more prominent (Pl. 22, fig. 4). In the following stages, from specimens measuring 31 mm. to 77 mm. in diameter, the mode of appearance of the radioles becomes more and more apparent and the vertical lines of primary tubercles more distinct (Pl. 22, figs. 5-10). In Pl. 22, figs. 5-7, the distinctness of the outer vertical zones and of the inner median zones becomes clearer with increasing size, and in the specimens of Pl. 22, figs. 8-10, of 67 to 77 mm. in diameter, the dotted lines on the radioles show the course of the primary vertical row with the dotted lines marking the position of the lateral and median vertical lines.

The denuded test of Pl. 24, fig. 4, corresponds nearly to that of Pl. 22, fig. 10, covered with spines; that of Pl. 22, fig. 6, to a stage intermediate between Pl. 24, figs. 2 and 3.

In a small specimen of *Podophora atrata* the actinal plates of the odd interambulacral zone did not show any trace of the primordial plate (Pl. 26, fig. 11).

The passage of the regular poriferous arcs into the laterally expanded poriferous field on the actinal side of a specimen 45 mm. in diameter is shown on Pl. 25, fig. 10, where the upper plate is on the abactinal surface and the lower plate on the actinal side of the test, the former having an arc of nine poriferous plates, the other of eleven pairs of pores arranged diagonally across the outer part of the plate, which is considerably larger than the plate above it (Pl. 25, fig. 10). The lower poriferous pair is pushed towards the median ambulacral line.

In a younger specimen of 8 mm. in diameter (Pl. 25, fig. 7), taking the same plates of the odd ambulacral zone partly on the actinal side and partly above the ambitus, we find on the abactinal side the same arc of nine poriferous plates arranged round the base of the primary ambulacral tubercle, and on the actinal side thirteen pairs of pores arranged diagonally across the outer side of the more elongated actinal ambulacral plates preceding it.

The arrangement of the arcs of poriferous plates on the abactinal side of the test is seen on Pls. 20, figs. 4, 6; 21, figs. 2, 3; 25, figs. 3, 4, 5, and the subsequently developed actinal poriferous field on Pls. 20, fig. 2; 21, fig. 1; 25, figs. 2, 6, 9. There are many miliaries in the poriferous field (Pl. 25, fig. 9) in marked contrast to their absence in *P. pedifera*.

A figure of *P. atrata* from the actinal side showing the arrangement of the poriferous field has been given by Lovén, (Études Pl. XVIII, fig. 158).

The arrangement of the abactinal part of the ambulacral system of *Podophora atrata* is somewhat different from that of *P. pedifera*. The youngest plate is at once followed by a plate cut in two by an upper poriferous plate extending across the ambulacral plate and followed by nine poriferous demi-plates; these extend from the edge of the interambulacral zone half way to the median ambulacral line (see Pl. 26, figs. 15, 16).

In an interior view of the abactinal part of the test (Pl. 25, fig. 5) the arrangement and number of the ambulacral plates are clearly drawn and the succession of the large and small ambulacral plates well indicated. In a part of the odd anterior ambulacrum of a larger specimen, 45 mm. in diameter, we can follow close to the ambitus the beginning of the widening of the

ambulacral plates and the flattening of the smaller intercalated plate (Pl. 26, fig. 14). In *Podophora atrata* there are larger miliaries than in *P. pedifera* along the median ambulacral line (Pl. 21, fig. 3).

In *P. atrata* the pavement of radioles covering the abactinal system is made up of more irregularly shaped radioles than in *P. pedifera* (Pl. 26, figs. 2, 4). Both the genital and ocular plates are more elongate than those of *P. pedifera*, and the genital plates carry from two to four small secondaries with a few small miliaries irregularly scattered. The ocular plates, as in *P. pedifera*, also carry one small secondary tubercle, with five to ten small miliaries (Pl. 26, fig. 3). In all the species both of *Colobocentrotus* and *Podophora* the ocular plates of the bivium are nearer the anal system than those of the trivium. The right anterior genital plate is nearly covered by the madreporite, and carries a few small secondaries along the median line with two or three clusters of miliaries.

In a smaller specimen (Pl. 25, fig. 3) there are few miliaries on the abactinal system (Pl. 26, fig. 1), with three to four secondary tubercles of uniform size on the genitals, and few miliaries. Seen from the interior (Pl. 25, fig. 5) the sutures of the abactinal system are well shown. The madreporite is a narrow band extending across the anterior extremity of the right anterior genital (Pls. 26, fig. 1; 25, fig. 3).

The genital pores are proportionally smaller in *P. atrata* (Pl. 26, fig. 3) than in *P. pedifera*, and are placed as in that species at the very tip of the genital plates. In the young specimen (Pl. 26, fig. 1) there is as yet no trace of genital pores, but the ocular pores are well developed.

Pl. 26, fig. 5 shows the anal system of a specimen measuring 8 mm. in diameter (Pl. 26, fig. 1), with eight plates covering the whole anal system. In a somewhat larger specimen the number of plates has increased, and they are not as regularly arranged. In a still larger specimen there are two rows of plates, the outer one being composed of large triangular ones (Pl. 26, fig. 7), and in a specimen of 45 mm. in diameter (Pl. 26, fig. 8) we have a magnified view of the anal plates of Pl. 26, fig. 3.

The principal types of radioles of *Podophora atrata* are represented on Pl. 23.

Fig. 1 is a small spine from the actinal membrane near the teeth.

Figs. 2-5 are from the odd ambulacrum and the left anterior interambulacrum near the actinal system.

Figs. 6-8 are views of a slightly flattened primary radiole from the left posterior interambulacrum from the actinal side of the ambitus.

Figs. 9-11 are drawings of the characteristic stout elliptical radioles of *P. atrata*, rounded or slightly pointed at the extremity, taken from the ambitus where they form a ring at the base of the pavement of polygonal radioles extending from the abactinal side of the ambitus to the apex. The ambital radioles are from 15 to 20 mm. in length, and of a dark violet color, almost black on the upper side; on the actinal side the color of the spines is yellowish or light brown. These large radioles are finely striated, of a dark violet, with a well-marked milled ring. Blainville writes "d'un violet foncé presque noir."

Figs. 12-14 are views of short triangular radioles from the ambitus which form a part of the abactinal polygonal pavement of the test; they are taken from the left posterior interambulacrum.

Figs. 15-17, views of a somewhat mushroom-shaped hexagonal or polygonal radiole taken from the abactinal side of the ambitus, from the right posterior ambulacrum.

Figs. 18-20 and figs. 21-23 are polygonal radioles taken from the right anterior interambulacrum from the abactinal side of the ambitus; and figs. 24, 25 is a similar radiole taken from the right posterior interambulacrum.

Figs. 26-28, drawings of a low mushroom-shaped asymmetrical polygonal radiole taken from half way between the ambitus and the abactinal system.

Figs. 29-31 is an irregularly hexagonal radiole taken from the genital plates; fig. 32 is a radiole taken from the madreporic genital; and fig. 33 represents a miliary spine hidden by the large pavement of abactinal primary radioles.

It will be seen on examining the figures of radioles given on Plate 23 that, with the exception of the spines of the actinal side and of the miliary spines, all the radioles are asymmetrical.

The striking difference between the radioles of *Podophora pedifera* and those of *Podophora atrata* is well shown on comparing Pl. 11, figs. 11-13; 14-16; 17, 18; 20-21; 22-24; 25-27; 28-30; 31-33 with Plate 23, figs. 1-8; 9-11; 12-14; 15-17; 18-20; 21-23; 26-28; 29-31. The most marked differences are in those of the ambital radioles (compare Pl. 11, figs. 11-13 with Pl. 23, figs. 9-11).

***Podophora pedifera* Agass.**

Plates 1; 3^a, figs. 1-4; 4-16, figs. 1-8; 31, figs. 1-4.

This species was figured in the Revision of the Echini (Pl. III^d, fig. 3), under the name of *Colobocentrotus atratus*, and noted as having been collected

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at Callao. A number of specimens were collected by the "Albatross" at Fakarava on the sea-face of the reef, during the Tropical Pacific Expedition, 1899-1900. An alcoholic specimen in the Museum collection is labelled Valparaiso? It would seem, therefore, that *Podophora pedifera* is characteristic of the Eastern Pacific, extending from Peru and Chili as far as the Western Paumotu, while the typical *Podophora atrata*, figured by Blainville, extends from the Hawaiian Islands to Mauritius, the Seychelles, and Zanzibar.

Seen from above the color of the test is olive green, darkest near the abactinal system, the pavement of radioles near the ambitus becoming lighter in color with a purplish tint; the large marginal spines are greenish with an occasional tinge of purple. Seen from the actinal side the color of the marginal and flattened elongated actinal spines is of a dirty yellow color, the large marginal radioles being of a light brownish pink at the tip. The actinal membrane is dark brown.

Podophora pedifera and *Podophora atrata* are readily distinguished. The row of primary, flat, truncated radioles which forms a close ring round the test at the ambitus in *P. pedifera* (Pls. 7, figs. 1-3; 9, figs. 4-6) is in striking contrast to the corresponding ring of radioles in *P. atrata*, which consists of flattened elliptical radioles rounded at the tip and well separated one from the other (Pl. 20, figs. 1, 3, 5). A comparison of the corresponding figures of Plates 7, 9, and Plates 20, 21^a, 21^b, shows this contrast at once. The abactinal radioles of *P. pedifera* above the ambitus form a close pavement of irregularly shaped low radioles closely fitting together, of a prevailing hexagonal outline, while the corresponding pavement of the low radioles of *P. atrata* consists of radioles of a rather rhomboidal or pentagonal outline and less frequently hexagonal (compare Pls. 20, figs. 3, 5; 21, figs. 4-6 with Pls. 7, figs. 2, 3; 9, figs. 5, 6). The outline of the test is higher, more arched in *P. pedifera* (Pls. 7, fig. 3; 8, fig. 3; 9, figs. 3, 6) than in *P. atrata*, which is flatter and slightly conical (Pls. 20, figs. 5, 6; 21, figs. 3, 6). *P. atrata* is very much flatter on the actinal side (Pls. 20, figs. 1, 2, 6; 21, figs. 1, 3, 4) than *P. pedifera* in which the actinostome is somewhat sunken (Pls. 8, figs. 1, 3; 9, figs. 1, 3, 4). The ambulacral poriferous zone is also proportionally much wider in *P. pedifera* (Pls. 8, fig. 1; 9, fig. 1) than in *P. atrata* (Pls. 20, fig. 2; 21, fig. 1) where the median rows of tubercles of the ambulacral zone extend far towards the actinostome (Pls. 20, fig. 2; 21, fig. 1), while in *P. pedifera* the corresponding ambulacral tubercles extend but little beyond the ambitus (Pls. 8, fig. 1; 9, fig. 1). The actinal interambulacral zone is also much broader

in *P. atrata* (Pls. 20, fig. 2; 21, fig. 1), while it is quite narrow in *P. pedifera* (Pls. 8, fig. 1; 9, fig. 1). In the latter there are two rows of small primary tubercles, while there are four in the former.

Figures 4 of Plates 9 and 21 show how large an area of the actinal surface is occupied by the closely packed ambulacral suckers, and we can judge of the great power exerted by these numerous suckers in keeping hold of the rock to which they are attached even when exposed to the full action of the surf on the outer beach of a coral reef. The sea has practically no hold on the pavement of radioles which covers the abactinal side of the test, and thus with the ambulacral suckers a cup is formed which it is difficult to detach from the rocks.

The large and small primary tubercles of *P. pedifera* are comparatively larger than those of *P. atrata*; the former occupy nearly the whole of the interambulacral and ambulacral plates leaving but little space for the smaller secondaries and miliaries, while in *P. atrata* the tubercles leave quite a part of the plate bare which carries a few miliaries and small secondary tubercles, and is covered by an indistinct granulation. In both these species the tubercles are most prominent, very glossy as if they were rounded beads made of wax (Pls. 8, 20, figs. 4, 6).

The tubercles diminish somewhat in size from the ambitus towards the abactinal system (Pls. 8, fig. 3; 9, fig. 3; 20, fig. 6; 21, fig. 3) which is covered by small secondary tubercles, with the exception of the anal system; but even that is completely hidden by the pavement of secondary radioles on the genital plates which lap over the anal system and conceal it (Pls. 7, fig. 2; 20, fig. 3, and Pls. 9, fig. 5; 21, fig. 5). The genitals carry a few miliaries. In both these species the anal system is covered with two or three irregularly concentric rows of small triangular plates (Pls. 9, fig. 2; 21, fig. 2). According to the size of the specimens there are in *P. pedifera* from six to eight large tubercles at the ambitus in the interambulacral areas forming six to eight vertical rows, of which only two extend to the actinal system. There are but two vertical rows of primary tubercles in the ambulacral zones (Pl. 9, fig. 3), with a few small miliaries along the median line. Towards the abactinal system a few small secondary tubercles occupy a part of the outer edges of the interambulacral plates. On the actinal side towards the actinostome the primary tubercles of the ambitus are soon replaced by small secondaries both in the ambulacral and interambulacral areas (Pls. 8, figs. 1, 3; 9, figs. 1, 3; 20, fig. 2; 21, fig. 1).

A comparison of the left anterior interambulacrum of a denuded specimen

of *Podophora pedifera* measuring 55 mm. in diameter (Pl. 12, fig. 1) with the same interambulacrum of *Podophora atrata* of a somewhat smaller specimen (Pl. 24, fig. 4) will show at once the great difference there is in the tuberculation of the two species of the genus *Podophora*. Their development results in the one case (*P. pedifera*) in a specimen of twelve and thirteen plates to four vertical rows, and in the other (*P. atrata*) to three vertical rows on each interambulacral plate in a specimen of twelve and twelve interambulacral plates. The narrowness of the actinal part of the interambulacral zone is very marked as contrasted to *P. atrata* (Pl. 12, fig. 1), as well as the extension of the lip of the gill slits to the fourth plate from the actinostome separating the two outer vertical zones from the inner ones. The difference in outline of the scrobicular areas and the mammary boss of this species (Pl. 12, figs. 2-6) is as marked as in *P. atrata*. There are fewer miliaries than in *P. atrata*, owing to the comparatively larger size of the primary tubercles which leave less space between the scrobicular areas of the primary tubercles for their development.

I have given figures on Plate 10 showing the order of development of the primary tubercles of some large specimens of *P. pedifera* measuring from 76 to 87 mm. in diameter (Pl. 10, figs. 1-6). We can trace in all the figures the radioles belonging to the two outer vertical rows, those of the primary row, and those adjacent to the median line. As will be seen on examining the figures, the position of the radioles shows the greatest regularity in the growth of the eight vertical rows of the interambulacral system of *P. pedifera* just as they did in the growth of the six vertical rows of the interambulacral zone of *P. atrata*. Seen from the interior of the test the plates of the right anterior interambulacra adjoining the actinal system show what seems to be the irregular remnant of the primordial plate (Pl. 14, fig. 8). Such a plate does not exist in the odd posterior interambulacrum (Pl. 14, fig. 9).

In a section of *P. pedifera* (Pl. 13, fig. 1) the outline of the test at the ambitus is seen to be pentagonal, the point of the pentagon running across the median line of the odd posterior interambulacrum. The pentagon of the actinal system runs in the opposite direction. The gradual narrowing up of the interambulacral plates at the ambitus is shown from the same figure, as well as the tufts of miliary spines rising at the base of flattened primary spines in both the ambulacral and interambulacral areas.

The abactinal part of the ambulacral system consists of simple pairs of pores, the secondary plates of which extend about two thirds across the primary plates (Pl. 13, fig. 8). The second plate has eight pairs of pores, the upper

plate only six; the ambulacral plates are much cut up, there being seven plates and demi-plates in the length of two plates.

The poriferous arcs extend down to a little above the ambitus (Pls. 8, figs. 2, 3; 9, figs. 2, 3), where the regular arrangement of the pores begins to be disturbed and they become crowded laterally, see Pls. 8, fig. 1; 9, figs. 2, 3. Below the ambitus on the actinal side the pairs of pores are thrown aside laterally and greatly crowded (Pl. 13, figs. 3, 4), as is shown in Pl. 13, fig. 3, on the actinal side, and Pl. 13, fig. 4, from the interior of the same plates. There are but few miliaries in the poriferous field (Pl. 13, fig. 3). The passage of the regular arcs into the broad poriferous field is well shown for *P. atrata* on Pl. 25, figs. 6/10. The apical system and the arrangement of the pores of the abactinal part of the ambulacral system of a large specimen measuring 82 mm. is seen on Pl. 14, fig. 4. In the second plate from the apex the upper demi-plate is followed by a row of seven poriferous plates which extend across the plate towards the median line, and beyond the projection of the large plate and its last pair of pores. When we come to the fifth ambulacral plate, counting from the actinal system, there are eleven pairs of pores arranged in a huge arc round the base of the primary tubercle. The upper pair is pushed out laterally well toward the median line (Pl. 13, fig. 6). The corresponding ambulacral plates seen from the interior (Pl. 13, fig. 7) are seen to be made up of a large plate and a narrow, elongated, and smaller plate, the large plate having nine intercalated poriferous demi-plates extending about two thirds across it from the side of the interambulacrum; the small plate having two intercalated poriferous plates. The inner line of sutures of the intercalated poriferous plates forms a slightly zigzag-shaped vertical line more or less parallel to the median ambulacral line.

In *P. pedifera* the actinal system is proportionally larger (Pls. 8, fig. 1; 9, fig. 1) than in *P. atrata*. The ratio of the actinostome to the test is as 28 to 46. The pairs of poriferous actinal plates are elliptical and larger than in *P. atrata*; they are more distant from the teeth and are fairly covered with secondaries and miliaries. The buccal membrane is nearly covered with a belt of crescent-shaped plates somewhat more closely packed distally from the five pairs of poriferous plates (Pl. 13, fig. 2). Between the teeth and the buccal poriferous plates there is a ring of small elliptical plates (Pls. 7, fig. 1; 8, fig. 1; 9, figs. 1, 4; 13, fig. 2).

The thin folds of the actinal cuts extend almost to the ambitus, enclosing in a sort of furrow the two rows of small secondary interambulacral

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ab /

tubercles which extend to the actinostome (Pls. 8, fig. 1; 9, fig. 1; 12, fig. 1).

In the abaectinal system of *P. pedifera* the genital plates (Pl. 14, fig. 3) carry from two to three large secondary tubercles with one to three very small secondaries or miliaries in the angles of the plates adjoining the anal system. The genital plates are irregularly heptagonal, the anterior plates elongate, the posterior broader than long. The ocular plates are pentagonal with a broad base curved towards the ambulacral system. They carry one large secondary tubercle, sometimes also a couple of miliaries, and have a well-marked ocular pore.

The madreporic genital is elongate, carries three large secondary tubercles, one in the centre of the plate, the others near the anal system, with five to six small secondaries. The madreporite occupies the greater part of the genital. Seen from above, covered with radioles, the abaectinal system (Pl. 14, fig. 1) forms a close pavement of irregular pentagonal plates which completely hide the anal system.

The genital pores are large. They occupy the distal points of the genital plates. They are well seen on Pl. 14, fig. 4, an interior view of the abaectinal system. This figure also shows the simple arrangement of the abaectinal pairs of pores above the few intercalated demi-plates. The anal system is circular, covered with three to four rows of small, irregular, elliptical plates.

There is a great contrast between the genital plates of *P. pedifera* (Pl. 14, fig. 3) with its three large secondary tubercles closely wedged together, and the genital plates of *P. atrata* with its four distant, large secondary tubercles (Pls. 25, fig. 8; 26, figs. 1, 3).

On Plate 11 has been figured a series of spines of a specimen measuring 82 mm. in diameter selected to represent the great difference and variation among the primary radioles of the ambital and abaectinal part of the test as well as of the spines of the actinal region and of the miliary spines hidden by the pavement of primary radioles of the abaectinal system (Pls. 11, fig. 1; 46-48). Figure 1 also shows the great development of the powerful muscular system which holds the radioles in place upon their corresponding primary tubercles. Figures 2-10 of Plate 11 show the shape of the radioles of the plates of the buccal membrane of the actinal system and of the first plates of the odd anterior ambulaerum and anterior interambulaerum. These radioles are all finely striated, somewhat club-shaped, slightly flattened towards the tip, with an indistinct milled ring and a deep socket at the base of the radioles.

The ambulacral radioles near the ambitus (Pl. 11, figs. 9, 10), are the first to show a marked flattening and to approach in outline the large, flattened, spatula-shaped radioles of the ambital region (Pl. 11, figs. 11-13, 14-16). The principal and most characteristic row of primary radioles (Pl. 11, figs. 11-13) is at the ambitus and it is the one which with the pavement of abactinal primary radioles gives to Colobocentrotus and Podophora their striking characteristics. These ambital radioles vary in length from 15 to 18 mm.; they are olive-green in color.

It is interesting to follow the gradual changes which take place in the ambital radioles (Pl. 11, figs. 11-13) as they are succeeded by the more abactinal radioles (Pl. 11, figs. 14-16) and gradually form more pavement-like, hexagonal, somewhat shorter radioles (Pl. 11, figs. 17, 18), to be followed by still shorter radioles (Pl. 11, figs. 19-21), and then the irregular, short, mushroom-shaped polygonal or hexagonal radioles (Pl. 11, figs. 22-24; 25-27; 28-30; 31-33), on the thirteenth plate counting from the actinostome. A series of small, mushroom-shaped radioles has also been selected from the ocular and genital plates. They continue the abactinal pavement over the abactinal system (Pl. 11, figs. 34-36; 37-39; 40, 41; 42, 43; 44, 45). The color of the primary radioles is olive green. It will be observed that with the exception of the radioles of the actinal side and of the miliary spines all the radioles are asymmetrical.

THE LANTERNS AND AURICLES OF COLOBOCENTROTUS AND PODOPHORA.

Plates 13, figs. 1-4; 14, figs. 5-7; 15; 26, figs. 9-13; 27; 28;
42, figs. 1-4; 43, figs. 4, 5; 44.

The differences in the various parts of the lanterns of *Podophora pedifera* and *P. atrata* are very marked; they are seen in the shape of the compass (Pls. 15, figs. 13 a b; 27, figs. 14 a b; 28, figs. 11 a b), in the proportions of the corrugations of the sides of the pyramid (Pls. 15, figs. 4, 5, 8, 9 a b; 27, figs. 4, 5, 7, 8 b; 28, figs. 4, 5, 7 b, 8 b); they are much coarser and less numerous in young specimens (see Pl. 27, figs. 4, 5, 7, 8). The foramen of the pyramids is longer in *P. pedifera* than in *P. atrata* (Pls. 15, figs. 2, 3; 27, 2, 3; 28, figs. 2, 3). The foramen formed by the apophyses and their hooklike appendages (Pl. 15, figs. 3, 4) is much larger than in young specimens of *P. atrata* (Pl. 27, figs. 3, 4), where it is rectangular; there are no hooks to the apophyses (Pl. 27, figs. 7, 8 a) while they are well developed in older speci-

mens (Pl. 28, figs. 3, 4, 7 a, 8 a) but do not compare in length with those of *P. pedifera* (Pl. 15, figs. 3, 4, 7 a, 9 a). The compass is distinctly jointed in *P. pedifera* and in the young of *P. atrata* (Pls. 15, fig. 13; 27, fig. 14); in the old of *atrata* there is no trace of any suture. The differences in the braces are very slight.

In *Colobocentrotus Stimpsoni*, the pyramids are broader at the summit (Pl. 44, figs. 3, 4) than the pyramids of the other species; the corrugations are coarser (Pl. 44, figs. 4, 5, 8 a, 9); the apophysal foramen is wider than that of *P. pedifera*, and the hooks are intermediate in length between those of *P. pedifera* and *P. atrata*. The compass is jointed (Pl. 44, figs. 12 a, b).

The auricles of a small specimen of *P. atrata*, 8 mm. in diameter, are not united (Pl. 26, figs. 9, 10); they touch in a specimen of 14 mm. (Pl. 26, fig. 12) and are connected in a specimen of 45 mm. (Pl. 26, fig. 13). In a large specimen of *P. pedifera* 82 mm. in diameter they are closely connected (Pl. 14, figs. 5, 6); the same is the case in a specimen of *Colobocentrotus Stimpsoni* of 88 mm. in diameter (Pl. 43, figs. 4, 5).

The pores close to the actinal system show how the ambulacral plates gradually increase in number and become resorbed as they move into the base of the auricles both from the actinal and the abactinal sides (see Pls. 14, figs. 5, 6; 26, figs. 12, 13; 43, figs. 4, 5; compare also Pl. 26, fig. 9 with Pl. 26, figs. 12, 13). The youngest poriferous plates are still seen on Pl. 14, fig. 6, and Pl. 43, fig. 4; somewhat older plates are shown on Pl. 14, fig. 7, which have been resorbed by the auricle (Pls. 14, fig. 5; 26, fig. 13); the upper part of the auricle in fig. 7, Pl. 14, is cut off.

THE SPICULES OF THE PEDICELS OF COLOBOCENTROTUS AND PODOPHORA.

Pls. 16; 45.

A large number of pedicels of *Colobocentrotus* and *Podophora* have been examined (Pls. 16, 45). They all agreed in having a disk made up of four basal plates; the periphery of the plates is angularly lobed. The number of lobes varies from seven to thirteen. In *Colobocentrotus Stimpsoni* (Pl. 45, figs. 1, 2) the plates have from twelve to thirteen lobes, while in the other species of the genus, *Colob. Mertensii*, the basal disks have usually not more than seven to nine lobes. See the figures of the disk of an actinal pedicel of *P. pedifera* (Pl. 16, figs. 1-7), of *P. atrata* (Pl. 16, figs. 9-11, 13) and of *Colob. Mertensii* (Pl. 45, fig. 7). At the base of the basal disk on the lower

side is found a set of three or four layers of yoke-shaped spicules (Pls. 16, fig. 6; 45, fig. 8). In *P. pedifera* the yoke-shaped spicules are nearly straight (Pl. 16, fig. 8), with a row of small perforations on the under side of the spicule. In *P. atrata* the yoke-shaped spicule is well arched (Pl. 16, fig. 12) with but few larger perforations.

These perforations frequently pass into more or less prominent teeth (Pl. 45, figs. 4, 6). The yoke-shaped spicules of *Colob. Stimpsoni* (Pl. 45, figs. 3-6) and *Mertensii* (Pl. 45, figs. 8, 9) have fewer perforations than those of *P. pedifera*, but more than those of *P. atrata*. The position of the layers of the yoke-shaped spicules with reference to the basal disks is well seen in Pl. 16, figs. 6, 9, 10, and Pl. 45, fig. 8. Fig. 14, Pl. 16, and fig. 10, Pl. 45, show the atrophied tip of an abactinal pedicel. No spicules were found in the tubes of the pedicels.

The changes due to growth in the appearance of the basal disk are shown in figs. 11 and 13, Pl. 16; the former is the basal plate of the pedicel of a denuded specimen of *P. atrata* measuring 8 mm. in diameter, the other of a pedicel from a specimen measuring ~~45~~ mm. with spines.

The basal disks of the other species were taken from specimens varying between 70 and 88 mm. in diameter including the spines; *P. pedifera*, 82 mm.; *Colob. Mertensii*, 70 mm.; *Colob. Stimpsoni*, 88 mm.

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THE PEDICELLARÆ OF COLOBOCENTROTUS AND PODOPHORA.

Plates 3^a; 4-6; 17-19; 29; 30.

The four kinds of pedicellariæ of *Podophora pedifera* are figured on Pl. 3^a, figs. 1-4. The rods vary but little in length, but the length of the necks differs greatly. In the tridentate pedicellariæ (Pl. 3^a, fig. 1) the neck is nearly twice as long as the rod; in the ophicephalous pedicellariæ (Pl. 3^a, fig. 2) it is but slightly longer than the rod.

The heads of the triphyllous and globiferous pedicellariæ are small (Pl. 3^a, figs. 3, 4), that of the triphyllous pedicellariæ being scarcely wider than the neck; this is about twice the length of the rod (Pl. 3^a, fig. 3), while the neck of the globiferous pedicellariæ is reduced to a minimum, the valves seeming to rest upon the head of the rod (Pl. 3^a, fig. 4).

The heads of the tridentate pedicellariæ of *Podophora atrata* seem to be somewhat more elongated and pointed (Pl. 3^a, fig. 5) than those of *P. pedifera*, and have a much shorter neck. The ophicephalous pedicellariæ

(Pl. 3^a, fig. 6) have a comparatively smaller head and longer neck. The triphyllous pedicellariæ (Pl. 3^a, fig. 7) are slightly larger, and the globiferous pedicellariæ (Pl. 3^a, fig. 8) larger than those of *P. pedifera*.

The tridentate pedicellariæ of *Colobocentrotus Mertensii* (Pl. 3^a, fig. 9) are closely allied to those of *P. atrata*, as are also the ophicephalous ones (Pl. 3^a, fig. ~~7~~¹⁰). The triphyllous pedicellariæ (Pl. 3^a, fig. ~~4~~¹¹) have a proportionally shorter neck and larger head than in the two species named above.

In the genus *Podophora* we find four kinds of pedicellariæ: the ophicephalous, tridentate, triphyllous, and globiferous. On Pls. 4-6 I have given figures of the valves of the four kinds taken from different parts of tests of *P. pedifera*. Their position is noted in the description of the Plates. The figures will give a far better idea of the characteristics of the pedicellariæ than any description I can give. Taking the figures of the valves of ophicephalous pedicellariæ of *P. pedifera* (Pls. 4, figs. 1-6; 11-17; 6) one cannot fail to be struck with the asymmetry of the valves, the great variation in the size and arrangement of the foramina, in that of the hinges, of the serrations of the edges, to say nothing of the great variation in the size of the ophicephalous pedicellariæ which vary from .33 mm. to .61 mm. in length; we note such extremes in the shape and the ornamentation of the ophicephalous pedicellariæ of *P. pedifera* as those of Pl. 6 figs. 1, 2, 4, 9, 10, 12, 14, 16, 17, taken from four individuals.

The valves of the globiferous pedicellariæ of the same species (Pls. 4, figs. 18-22; 5, figs. 10-13) taken from three specimens show equally great differences in shape, size, and ornamentation; they vary from .21 mm. to .37 mm. in length, and even of the triphyllous pedicellariæ figured (Pl. 5, figs. 7-9) no two of the valves are alike.

We finally come to the tridentate pedicellariæ of *P. pedifera* (Pls. 4, figs. 7-10; 5, figs. 1-6) varying in length from .86 mm. to .99 mm. The figures are from pedicellariæ taken from five specimens, and they speak for themselves. No two are alike, either in shape, size, outline, or ornamentation.

The tridentate pedicellariæ of *P. atrata*, figured on Pls. 18, figs. 1-6, 13-16; 19, figs. 1-13, were taken from three specimens. The valves vary in length from .41 mm. to .90 mm. The blade of *P. atrata* is much more elongate than the blade of *P. pedifera*. The variation in the serration of the edge of the blade is very marked (compare Pl. 18, figs. 6, 15, 16 with the same

edge of Pl. 19, figs. 1, 2, 3, 10, 11). In one case the serration is limited to a few large teeth, in the other the edge is serrated for the whole length of the blade. The size and arrangement of the foramina of the valve both of the basal part and of the blade also varies greatly. In many of the valves the base passes very gradually into the blade (Pl. 19, figs. 7-10), in others the junction is sharply marked (Pl. 18, figs. 4, 5), and in others the outline of the base is quite irregular (Pl. 18, figs. 1-3). It would be difficult to say which of these pedicellariæ are typical of *P. atrata*; as in *P. pedifera* the valves of the triphyllous pedicellariæ (Pls. 18, figs. 10-12; 19, figs. 14-16) vary greatly in outline and in ornamentation. The valves figured were taken from two specimens; they vary in length from .11 mm. to .16 mm.

Compared with the globiferous pedicellariæ of *P. pedifera*, though they vary greatly (Pls. 4, figs. 18-22; 5, figs. 10-13), those of *P. atrata* (Pl. 18, figs. 17, 18) do not show any important differences.

One of the ophicephalous pedicellariæ of *P. atrata* is figured on Pl. 18, figs. 7-9. The edge of the valves is more finely serrated than in the majority of the ophicephalous pedicellariæ of *P. pedifera*, but some of them are fully as finely serrated as those of *P. atrata*.

Owing to the great variation in the valves, neither the ophicephalous pedicellariæ of *Colob. Stimpsoni* (Pl. 29, figs. 1-6, 10-13, 16), varying in length from .36 mm. to .51 mm., nor those of *Colob. Mertensii* (Pl. 30, figs. 1, 2, 9, 12-15), varying in length from .27 to .48 mm. show any character by which it would be possible to distinguish these two species, or to distinguish them in turn from *P. pedifera* or *P. atrata*. It is quite possible to select ophicephalous pedicellariæ of *P. pedifera* and *Colob. Stimpsoni* which are very similar, and which it would be difficult to distinguish (see Pl. 6, fig. 10 and Pl. 29, fig. 13). The valves of the triphyllous pedicellariæ of *Colob. Stimpsoni* (Pl. 29, figs. 14-15) appear to be somewhat more slender than those of *Colob. Mertensii* (Pl. 30, figs. 10-11, 16), and the foramina of the valves of the triphyllous pedicellariæ of these two species are perhaps, on the whole, smaller than those of *P. pedifera* and *P. atrata*.

The tridentate pedicellariæ of *Colob. Stimpsoni* (Pl. 29, figs. 7-9) and those of *Colob. Mertensii* (Pl. 30, figs. 3-8) resemble more the general pattern of those of *P. pedifera*, but in this case also the difference in the ornamentation of the valves, in the proportions of the base to the blade makes it impossible to designate any one figure as a typical tridentate valve of either species.

The valves of the tridentate pedicellariæ of *Colob. Stimpsoni* vary in length from .78 mm. to .88 mm.; those of *Colob. Mertensii* from .41 to .81 mm.

THE CYSTACANTHS AND SPHÆRIDIA OF COLOBOCENTROTUS AND PODOPHORA.

Pls. 1-3; 31; 32.

A comparison of the sphæridia of the species of *Colobocentrotus* and *Podophora* shows at once how variable they are and how misleading their characters seem as guides to the affinities of the species of the genus. From a first glance at the figures of Pls. 31 and 32, we would arrange on one side the more or less cylindrical sphæridia of *P. pedifera* (Pl. 31, figs. 1-4), and the three other species with globular sphæridia on the other. Yet no one would attempt to say that *P. atrata* is more closely allied to *Colob. Stimpsoni* and *Colob. Mertensii* than to *P. pedifera*, as would be legitimate from the sphæridia alone.

Pl. 13, fig. 5, shows a line of sphæridia on the actinal part of the right ambulacral zone. The great variation which exists in the sphæridia of *P. pedifera* / ~~*atrata*~~ is well seen on comparing the figures of sphæridia taken from different parts of the same individual (measuring 82 mm. in diameter, including the spines), viz., the left sphærid of Pl. 31, fig. 1, the left of fig. 2, the middle of fig. 3, and the right of fig. 4, taken respectively from the right posterior ambulacrum, the odd anterior ambulacrum, the left anterior ambulacrum, and the left posterior ambulacrum. They vary in length from .19 mm. to .34 mm., and in outline are cylindrical, elliptical, or club-shaped. 57/

In *P. atrata* the variation in shape is not as marked (Pl. 31, figs. 5-8), yet there are such extremes in shape as the right sphærid of Pl. 31, fig. 6, and the right sphærid of Pl. 31, fig. 7, the one measuring .20 mm., 57/ the other .25 mm. in length; both were taken from the same specimen of 6/ 77/65 mm. in diameter including the spines; the one from the odd anterior ambulacrum, the other from the left posterior ambulacrum.

One might think, on examining the figures of Plate 32, that the sphæridia of *Colob. Stimpsoni* and *Colob. Mertensii* differed but little if the comparison is made between such sphæridia as Pl. 32, figs. 1, 4, and Pl. 32, fig. 7, and the central figure of fig. 5. When we come to compare such extremes of *Colob. Stimpsoni* as Pl. 32, fig. 1, with the extremes of *Colob. Mertensii* (Pl. 32, fig. 6), the differences are most striking; while a comparison of the left figure of Pl. 32, fig. 7 (*Colob. Mertensii*) with the left figure of Pl. 32, fig. 3 (*Colob.*

Stimpsoni) would show that they are specifically identical; again such sphaeridia of *Colob. Stimpsoni* (Pl. 32, fig. 4, right-hand figure) and the third figure of Pl. 32, fig. 6 (*Colob. Mertensii*) should leave no doubt of their specific difference.

The sphaeridia of *Colob. Stimpsoni* were taken from the left posterior and the left anterior ambulacra of a specimen measuring 88 mm. in diameter, and those of *Colob. Mertensii* from the odd anterior and the left anterior ambulacrum of a specimen measuring 77 mm. in diameter including the spines, the sphaeridia varying in length from .23 to .27 mm. *O/*

The great variation in the shape of the sphaeridia and of the pedicellariæ, depending in great measure on the position they occupy, does not seem to make these organs important factors in the ultimate classification of Echini, as has been maintained by some recent writers. At any rate, in the genera *Colobocentrotus* and *Podophora* we have no basis, from the data obtained by the examination of the pedicellariæ, upon which to build the identification of the species of this genus. We are led to the belief that while their examination is certainly most interesting and instructive as far as the general groups of Echini are concerned, the application of the special details they furnish can only bring about endless confusion when applied to the classification of the genera and species of Echini, not only to the exclusion of other characters, but also when given an inordinate importance in connection with other structural features of the group.

While examining some specimens of *P. pedifera* Mr. M. Westergren observed in the median line of the actinal part of one of the ambulacra peculiar organs, a group of which has been figured on Pl. 1, fig. 1. They might at first sight be taken for clusters of poison glands of some globiferous pedicellariæ. These organs are small, the sacs with the spine rarely measuring more than one millimeter in length. Five or six are found on the actinal side of each ambulacrum (Pl. 1, fig. 1). They consist in *P. pedifera* of three spherical sacs surrounded by an envelope (Pl. 1, figs. 3, 4). Each sac has a pore which in the smaller organs has a more or less pentagonal shape. The larger sacs seem when expanded to have forced out one or more transparent bladders (Pl. 1, figs. 2-4). I could not detect any spicules or other calcareous deposits in any of these diminutive organs which we may call cystacanth. Only one of the sacs is attached to the extremity of a minute spine, greatly resembling the rods of pedicellariæ.

On Pl. 1 are given a number of figures showing the cystacanth of *P. pedifera*

from different sides. They are drawn from a dried specimen, the sacs having been treated with alcohol and glycerine. The cystacanths of *P. atrata* differ greatly from those of *P. pedifera*. The sacs are more closely compressed, forming a club at the top of the rod (Pl. 2, figs. 1-3). The bladders contained in the sacs are much thicker than those of *P. pedifera*. The sacs are also irregularly dotted with black spots. The cystacanths of *P. atrata* are found on the abactinal extremity of the ambulacrum, close to the ocular plates, and are absent from the actinal side. Pl. 1, figs. 1, 2 are drawn from an alcoholic specimen.

In *Colob. Stimpsoni* the cystacanths are comparatively larger (Pl. 2, figs. 4-7), but coming from a dried specimen they have lost their globular shape and the existence of pores could not be traced. The sacs seem tougher than those of *P. pedifera*. In one of the figures (Pl. 2, fig. 5) a few spicules could be detected.

The cystacanths of *Colob. Mertensii* (Pl. 2, figs. 8-12) are elongate, resembling more those of *Colob. Stimpsoni*. They showed no pores. The spines of the cystacanths (figs. 11, 12) resemble those of tridentate pedicellariæ (Pl. 2, fig. 13) but they expand somewhat more at the tip.

In *Chaetodiadema pallidum* A. Ag. and Clark, cystacanths (Pl. 3) are found only around the abactinal system, mainly upon the interambulacral plates. They apparently vary far more in shape than in the species of *Colobocentrotus* and *Podophora*. The cystacanths of Pl. 3, figs. 5, 6, 7, 8 are somewhat club shaped like those of *P. atrata*. They show well developed pores (Pl. 3, figs. 2, 3, 5, 7, 11). Others (Pl. 3, fig. 1) look more like the wrinkled sacs of the cystacanths of *Colob. Stimpsoni*. Others again consist only of a single elongated sac (Pl. 3, figs. 2, 9). Transparent bladders like those seen in *P. pedifera* are seen on Pl. 3, figs. 1, 2, 11. It will be interesting to see if cystacanths are found in other echini and to obtain, if possible, some clue to the function of these problematical organs which suggest affinities both to the poison glands of globiferous pedicellariæ and to the sac-carrying spines of *Echinothuria*.

On Pl. 12, figs. 8-10 of the Ingolf Ex. Echini, Dr. Mortensen gives sections of an organ which remind one of cystacanths, but he calls them globiferous pedicellariæ, though they seem to be without valves or other calcareous deposits. He gives no further explanation of their structure in describing the globiferous pedicellariæ of *Haplos. pellucidum*.

Cystacanths vary greatly in number in different specimens, and their occur-

rence is not limited to the ambulacra near the sphæridia, nor are they limited to the ambulacra. They are found both in the ambulacral and interambulacral areas and on the actinal as well as the abactinal sides.

I can only offer suggestions as to the nature of the cystacanth. I have no observations of any value regarding their function. They may be modified sac-bearing spines such as are found among the Echinothuriæ or modified pedicellariæ in which the glands have developed into the glands of the cystacanth at the expense of the valves.

EXPLANATION OF THE PLATES.

PLATE 1.

PLATE 1.

1-12. *Podophora pedifera* Agass.

1-11. Cystacanths from a specimen 82 mm. in diameter, including the spines.

1. Left posterior ambulacrum, actinal side, showing a group of cystacanths.
2. Expanded cystacanth, 0.92 mm.
3. Side view, of another specimen, 0.92 mm.
4. Seen from above, specimen of 0.90 mm.
5. Less developed with only three cysts, 0.66 mm.
6. Another stage with three cysts, 0.60 mm.
7. Showing the mode of attachment of the cysts to the spine, 0.71 mm.
8. Profile of cystacanth of 0.54 mm.
9. Same, front view.
10. Side view of one of the smallest cystacanths with three cysts, 0.41 mm.
11. The same, rear view.
12. Pedicellaria, to show its comparative size to the cystacanths.

All the figures equally magnified, measurements indicate the natural size of the sacs without the spine.

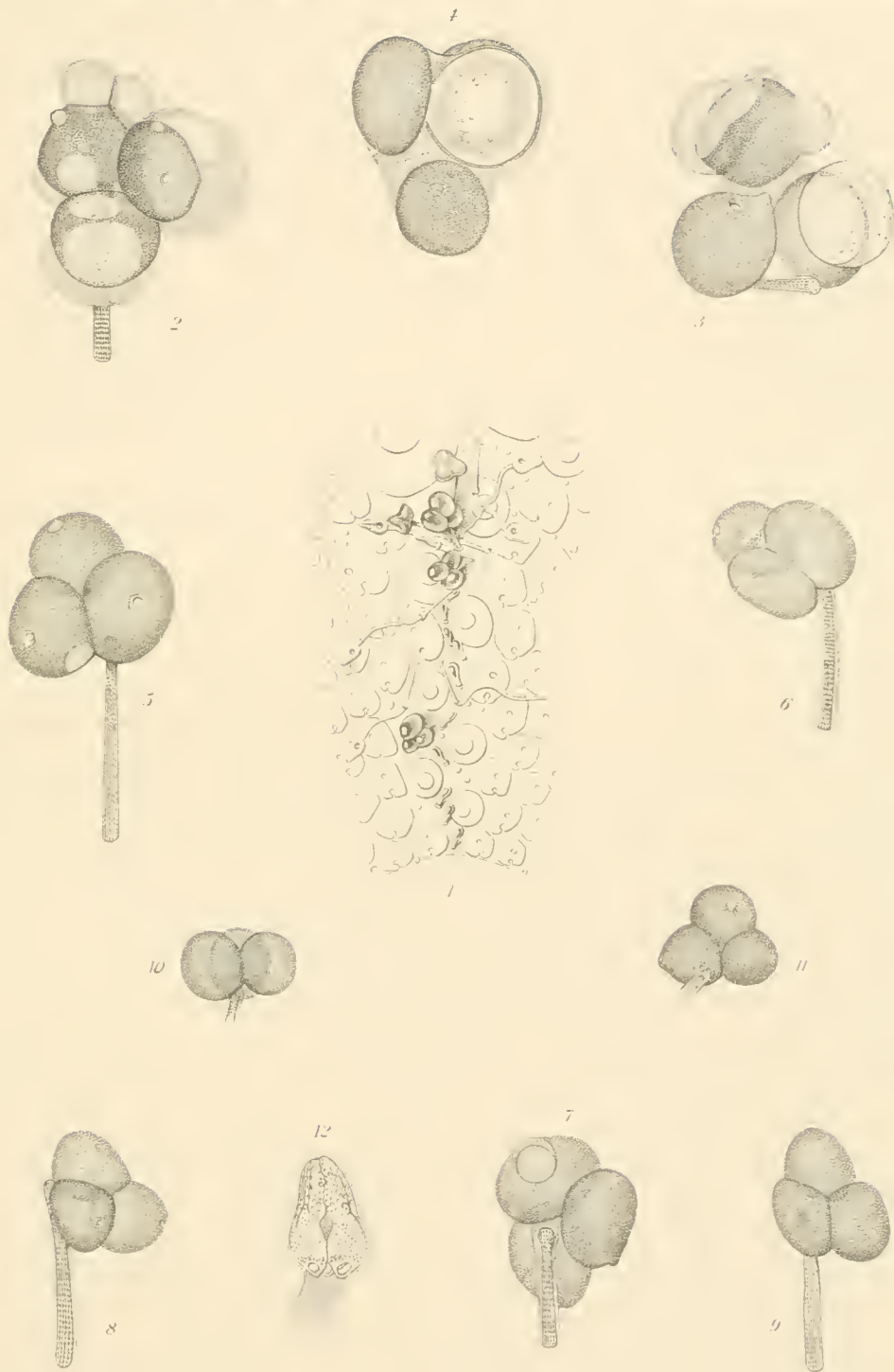


PLATE 2.

PLATE 2.

1-3. *Podophora atrata* Agass.

1-3. Cystacanths from the abactinal side of a specimen 65 mm. in diameter, including the spines.

1. From the left posterior ambulacrum, near the ocular plate, front view, 0.37 mm.
2. In the same ambulacrum, but less expanded, 0.39 mm.
3. Profile, from the same ambulacrum, 0.29 mm.

4-7. *Colobocentrotus Stimpsoni* A. Ag.

4-7. Cystacanths from a specimen of 88 mm. diameter with spines.

4. Shows the attachment of the spine to the third lobe, 0.94 mm. from the left anterior ambulacrum, actinal side.
5. Front view of a cystacanth 0.60 mm. from the right anterior ambulacrum.
6. Same view of a cystacanth 0.58 mm. from the left posterior ambulacrum.
7. Profile of a cystacanth 0.70 mm. near the ambitus, from the right posterior ambulacrum.

8-13. *Colobocentrotus Mertensii* Brandt.

8-13. Cystacanths from a specimen 70 mm. in diameter including spines.

8. Contracted, with spine, 1.15 mm. close to the ambitus, from the odd anterior ambulacrum.
9. Rear view, 0.44 mm. from the left anterior ambulacrum.
10. Seen from beneath, 0.59 mm. near the ambitus, from the left anterior ambulacrum.
11. Spine of a cystacanth.
12. Upper end of same, somewhat more magnified.
13. Spine of a pedicellaria.

All the figures are equally magnified; measurements indicate the natural size of the sacs without spine.



PLATE 3.

PLATE 3.

1-11. *Chaetodiadema pallidum* A. Ag. and Cl.

1-11. Cystacanths, from the abactinal side of the amubulacral and interambulacral plates round the summit of a specimen 55 mm. in diameter.

1. Front view of a somewhat contracted double cyst, 1 mm.
2. Single cyst, 1.30 mm. magnification of the drawing reduced one half.
3. Expanded, showing the pavement of epithelial cells and the two pores, 0.73 mm.
4. Shows a line of glands, 0.61 mm.
5. Cystacanth with epithelial cells, 0.66 mm.
6. Profile, showing a string of glands, 0.60 mm.
7. Front view with pores, 0.53 mm.
8. Cystacanths similar in form to fig. 7, 0.56 mm.
9. Profile of a cystacanth, 0.73 mm.
10. Younger stage, 0.55 mm.
11. Similar to fig. 10 with large pores, 0.36 mm.

The figures are equally magnified except 2; measurements give the natural size of the cyst with its spine.

"Albatross" Ex. 1902. Station 4104.

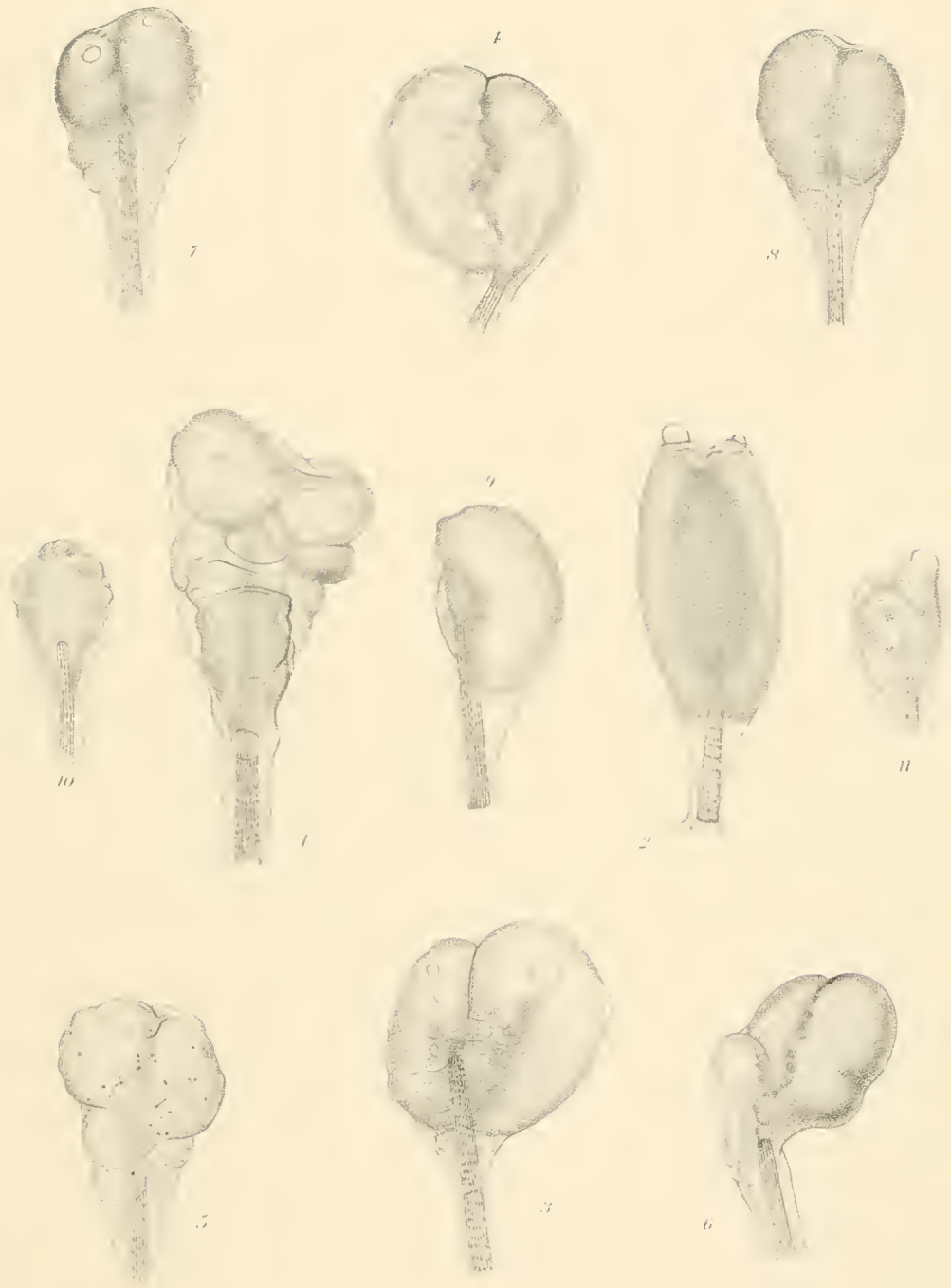


PLATE 3a.

PLATE 3a.

1-4. *Podophora pedifera* Agass.

From a specimen 74 mm. in diameter, including the spines.

1. Tridentate pedicellaria. 3.9 mm.
2. Ophicephalous pedicellaria. 2.9 mm.
3. Triphyllous pedicellaria. 2.2 mm.
4. Globiferous pedicellaria. 1.4 mm.

5-8. *Podophora atrata* Agass.

From a specimen 68 mm. in diameter, including the spines.

5. Tridentate pedicellaria. 2.1 mm.
6. Ophicephalous pedicellaria. 1.5 mm.
7. Triphyllous pedicellaria. 1.2 mm.
8. Globiferous pedicellaria. 1.4 mm.

9-11. *Colobocentrotus Mertensii* Brandt.

From a specimen 72 mm. in diameter, including the spines.

9. Tridentate pedicellaria. 2.7 mm.
10. Ophicephalous pedicellaria. 1.9 mm.
11. Triphyllous pedicellaria. 2.7 mm.

All the figures are of relative sizes and under the same enlargement; the measurements indicate the greatest length of the pedicellariæ in the positions in which they are drawn.



PLATE 4.

PLATE 4.

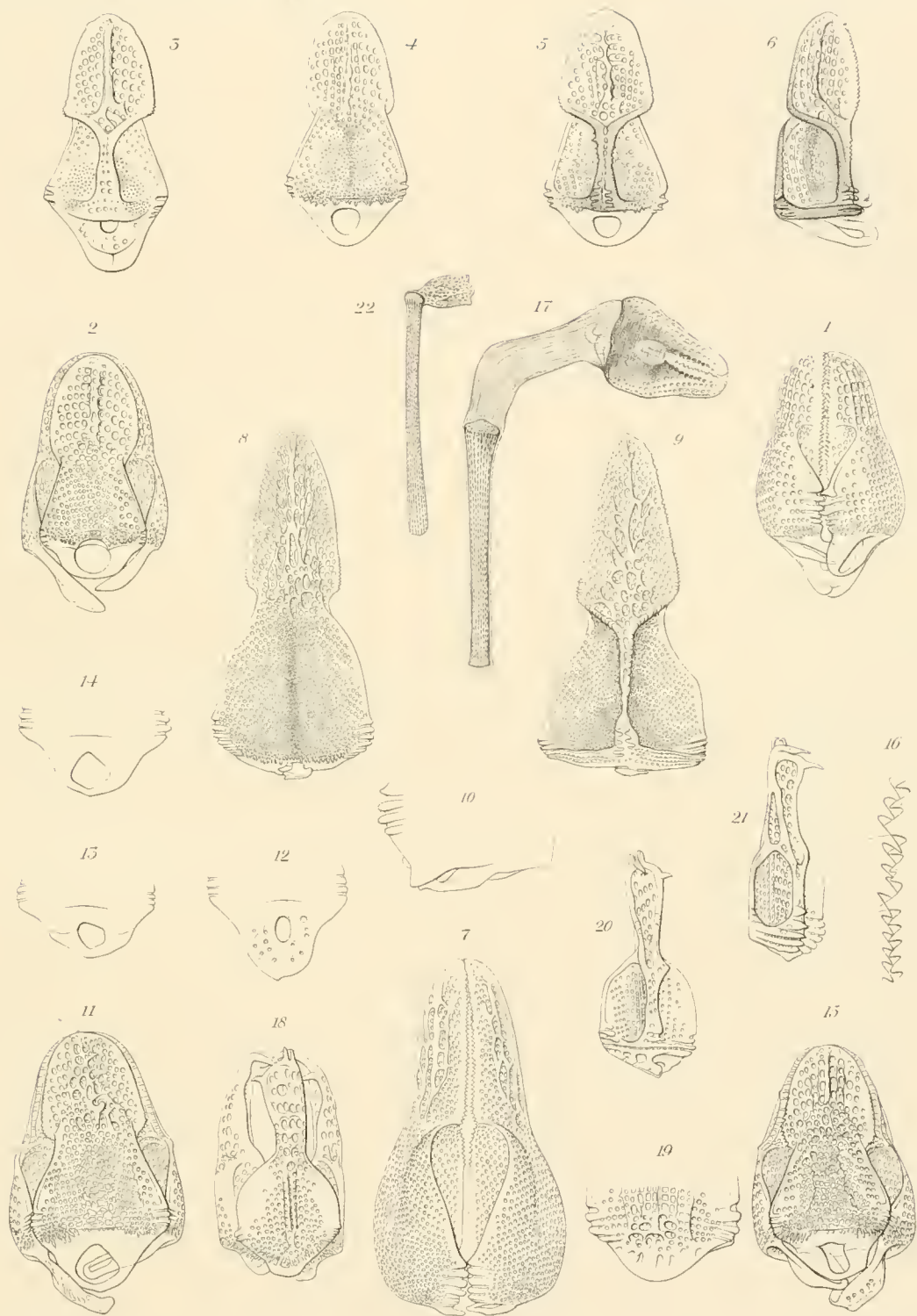
1-22. *Podophora pedifera* Agass.

1-22. Valves of Pedicellariæ.

1. Valve of an Ophicephalous pedicellaria, in profile, from the buccal membrane near the teeth.
2. Valve of an Ophicephalous pedicellaria, another view of the same (fig. 1).
3. Valve of an Ophicephalous pedicellaria, interior of a valve of the same.
4. Valve of an Ophicephalous pedicellaria, similar to 3; exterior view.
5. Valve of an Ophicephalous pedicellaria, interior view of same.
6. Valve of an Ophicephalous pedicellaria, profile of same.
7. Valve of an Tridentate pedicellaria, from the right anterior ambulacrum, not far from the actinal system.
8. Valve of a Tridentate pedicellaria, the same as 7; external view.
9. Valve of a Tridentate pedicellaria, the same as 7; internal view.
10. Valve of a Tridentate pedicellaria, the same as 7; profile of the articulation.
11. Valve of an Ophicephalous pedicellaria, from the left anterior ambulacrum, nearer the ambitus than to the actinal system.
- 12, 13, 14. Details of the same pedicellaria as 11; articulations of each valve.
15. Valve of an Ophicephalous pedicellaria, from the left posterior interambulacrum, midway between the actinal system and the ambitus.
16. Serration from same as 15.
17. Stalk and head of an Ophicephalous pedicellaria.
18. Valve of a Globiferous pedicellaria, from the apical part of the left anterior ambulacrum.
19. Detail of an articulation seen from the exterior, the same as 18.
20. Interior the same as 18.
21. Exterior the same as 18.
22. View of the stalk and head of a globiferous pedicellaria.

The figures are about equally enlarged with the exception of 1-6, which are somewhat larger.

Outer reef, Fakarava, Paumotu, "Albatross" Ex., 1899-1900.



A.M. Westergren del

B. Meisel lit

PLATE 5.

PLATE 5.

1-13. *Podophora pedifera* Agass.

1-13. Valves of Pedicellariæ, seen from the exterior.

1. A valve of a Tridentate pedicellaria, 0.86 mm. from the left anterior ambulacrum, near the actinal system of a specimen 73 mm. in diameter.
2. A valve of a Tridentate pedicellaria, 0.91 mm. from the left anterior ambulacrum, close to the actinal system of a specimen 75 mm. in diameter.
3. A valve of a Tridentate pedicellaria, 0.94 mm. from the left posterior interambulacrum, close to the actinal system, from the same specimen as 2.
4. A valve of a Tridentate pedicellaria, 0.98 mm. from the right anterior interambulacrum, near the actinal system of a specimen 77 mm. in diameter.
5. A valve of a Tridentate pedicellaria, 0.99 mm. from the left anterior ambulacrum, close to the actinal system of a specimen 80 mm. in diameter.
6. A valve of a Tridentate pedicellaria, 0.94 mm. from the right anterior ambulacrum midway between the actinal system and the ambitus, from a specimen 82 mm. in diameter.
7. A valve of a Triphyllous pedicellaria, 0.13 mm. from the right posterior ambulacrum, at the ambitus, from a specimen 68 mm. in diameter.
8. A valve of a Triphyllous pedicellaria, 0.14 mm. from the odd anterior ambulacrum, near the actinal system of the same specimen as 7.
9. A valve of a Triphyllous pedicellaria, 0.13 mm. from the left posterior ambulacrum, midway between the actinal system and the ambitus of the same specimen as 7.
10. A valve of a Globiferous pedicellaria, 0.22 mm. from the odd anterior ambulacrum, near the apical system, from a specimen 72 mm. in diameter.
11. A valve of a Globiferous pedicellaria, 0.37 mm. from the right posterior ambulacrum near the actinal system of the same specimen as 10.
12. A valve of a Globiferous pedicellaria, 0.22 mm. from the odd anterior ambulacrum, nearer the ambitus than the abactinal system, from a specimen 74 mm. in diameter.
13. A valve of a Globiferous pedicellaria, 0.21 mm. from the odd anterior ambulacrum, midway between the ambitus and the abactinal system, from a specimen 83 mm. in diameter.

The measurements of the diameter of the specimens include the spines. The dimensions given of the pedicellariæ are natural size. The corresponding valve was selected for each figure.

Outer reef, Fakarava, Paumotu, "Albatross" Ex., 1899-1900.



PLATE 6.

PLATE 6.

1-17. *Podophora pedifera* Agass.

1-17. Exterior views of valves of Ophicephalous pedicellariæ.

1. A valve 0.35 mm. adjoining the teeth, from a specimen 73 mm. in diameter.
2. A valve 0.44 mm. adjoining the teeth, from a specimen 75 mm. in diameter.
3. A valve 0.36 mm. adjoining the teeth, from a specimen 82 mm. in diameter.
4. A valve 0.53 mm. from the right posterior ambulaerum, near the ambitus, of a specimen 68 mm. in diameter.
5. A valve 0.59 mm. from the right anterior ambulaerum, midway between the actinal system and the ambitus of the same specimen as 4.
6. A valve 0.55 mm. from the left anterior ambulaerum, near the actinal system of the same specimen as 4.
7. A valve 0.57 mm. from the right posterior interambulaerum, near the actinal system of a specimen 72 mm. in diameter.
8. A valve 0.59 mm. from the left anterior interambulaerum, near the actinal system of the same specimen as 7.
9. A valve 0.57 mm. from the right anterior ambulaerum, midway between the actinal system and the ambitus of a specimen 73 mm. in diameter.
10. A valve 0.48 mm. from the right anterior ambulaerum, at the ambitus of a specimen 75 mm. in diameter.
11. A valve 0.59 mm. from the odd anterior ambulaerum, midway between the actinal system and the ambitus, of the same specimen as 10.
12. A valve 0.61 mm. from the odd posterior interambulaerum, near the ambitus, of the same specimen as 10.
13. A valve 0.57 mm. from the odd posterior interambulaerum, near the actinal system of a specimen 77 mm. in diameter.
14. A valve 0.54 mm. from the left anterior interambulaerum, at the ambitus of a specimen 82 mm. in diameter.
15. A valve 0.56 mm. from the right posterior ambulaerum, midway between the actinal system and the ambitus of a specimen 85 mm. in diameter.
16. A valve 0.48 mm. from the odd posterior interambulaerum at the ambitus of the same specimen as 15.
17. A valve 0.38 mm. from the left posterior interambulaerum at the ambitus of the same specimen as 15.

The measurements of the diameter of the test include the spines, with the exception of 1, 2, 4, 5, 6, 14, and 15, which are denuded. The corresponding valve was selected for each figure. The figures are about equally magnified with the exception of 1-3, which are somewhat larger. The dimensions given of the valves of the pedicellariæ are natural size.

Outer reef, Fakarava, Paumotu, "Albatross" Ex., 1899-1900.



PLATE 7.

PLATE 7.

1-3. *Podophora pedifera* Agass.

1. Seen from the actinal side.
2. The same specimen seen from the abactinal side.
3. The same specimen seen in profile, facing the odd anterior ambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figures 1 and 2.

All figures are natural size.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899-1900.

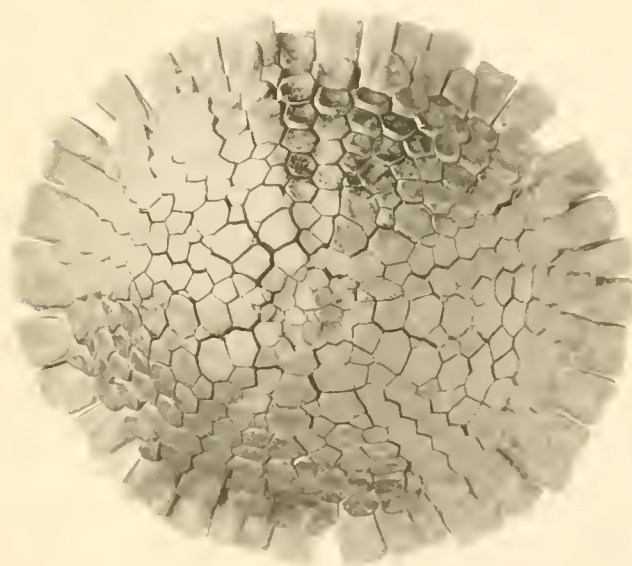
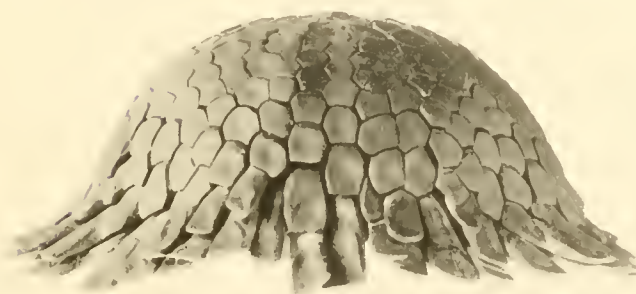
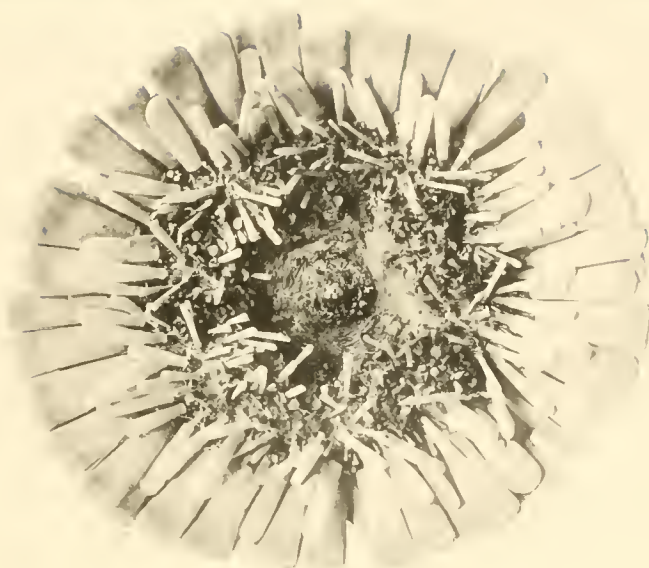


PLATE 8.

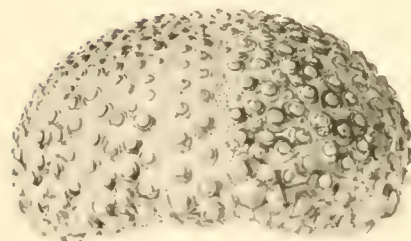
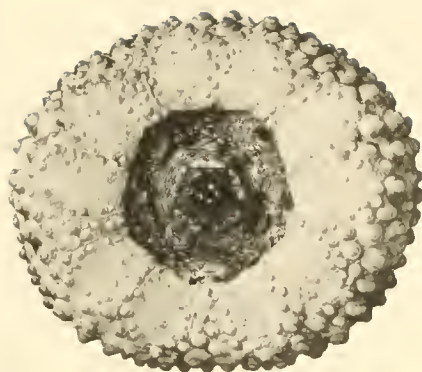
PLATE 8.

1-3. *Podophora pedifera* Agass.

1. Denuded test, seen from the actinal side.
2. The same specimen seen from the abactinal side.
3. The same specimen seen in profile, facing the odd anterior ambulacrum.

All figures are natural size.

The odd anterior ambulacrum occupies the center of the upper part of figs. 1, 2.
Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899-1900.



5



PLATE 9.

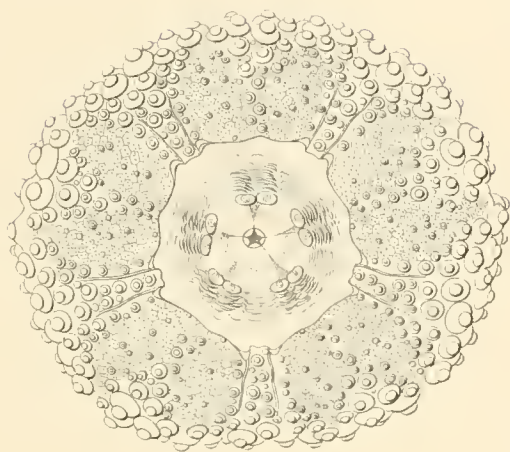
PLATE 9.

1-6. *Podophora pedifera* Agass.

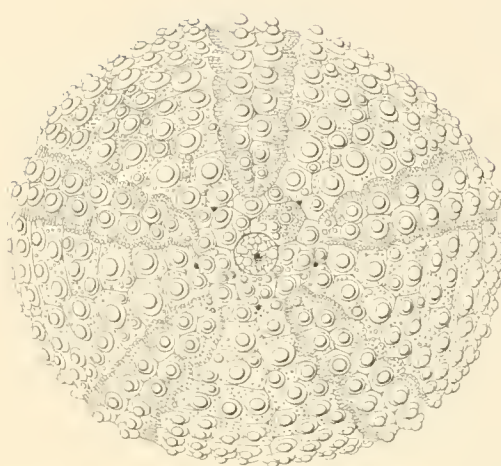
1. Denuded test, seen from the actinal side, measuring 55 mm. in diameter.
2. The same, from the abactinal side.
3. The same in profile, facing the odd anterior ambulacrum.
4. Actinal side of a specimen measuring 82 mm. in diameter, including the spines.
5. The same specimen seen from the abactinal side.
6. The same specimen seen facing the odd posterior interambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figures 1, 2, 4, 5.
Outer reef, Fakarava Paumotus, "Albatross" Ex., 1899-1900.

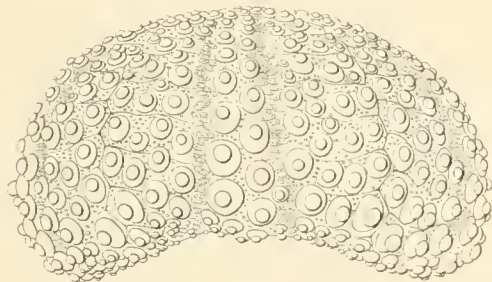
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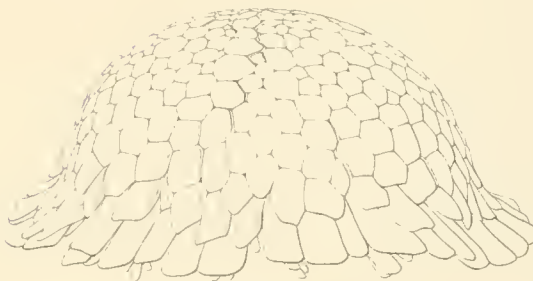
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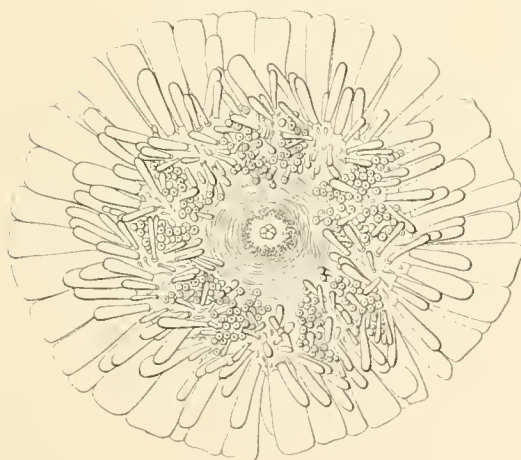
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5



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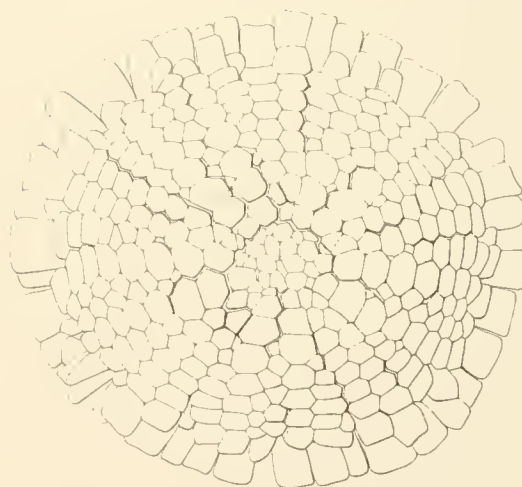


PLATE 10.

PLATE 10.

1-6. *Podophora pedifera* Agass.

1. Odd posterior interambulacrum, and left posterior with part of right posterior ambulacrum, showing the grouping of the spines of a specimen measuring 75 mm. in diameter, including the spines.
2. The same portion of the test as in 1 of a specimen, 76 mm. in diameter.
3. The same portion of the test as in 1 of a specimen 77 mm. in diameter.
4. The same portion of the test as in 1 of a specimen 80 mm. in diameter.
5. The same portion of the test as in 1 of a specimen 82 mm. in diameter.
6. The same portion of the test as in 1 of a specimen 87 mm. in diameter.

The dotted lines unite the primary radioles belonging to the same vertical row.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899-1900.

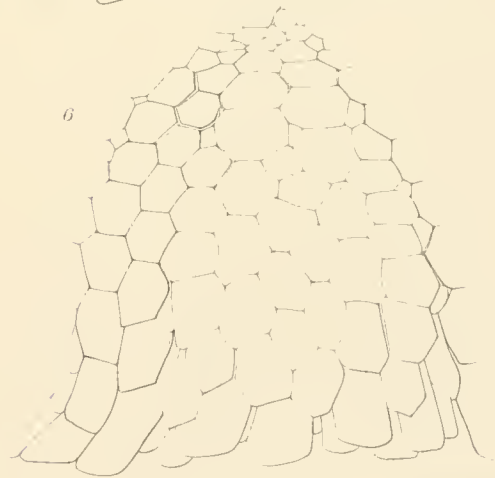
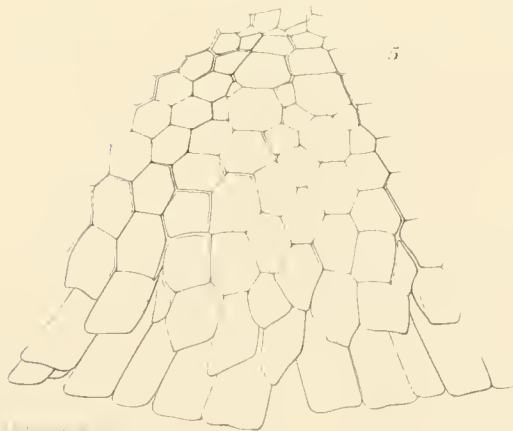
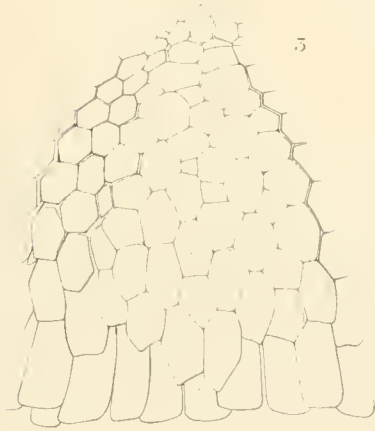
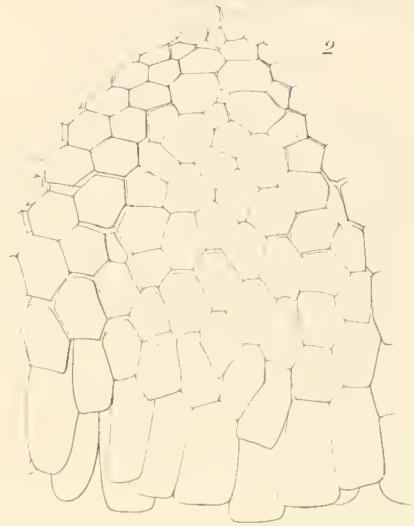
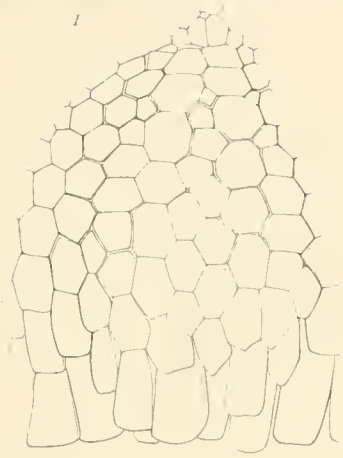


PLATE 11.

1-48. *Podophora pedifera* Agass.

1-48. Spines, from a specimen 82 mm. in diameter.

1. Spines seen in profile, taken from the left posterior ambulacrum towards the apical system.
2. Spine, from a poriferous plate of the buccal membrane.
3. Spine, from the first plate at the actinal system of the odd anterior ambulacrum.
4. Spine, from the second plate, of the left anterior interambulacrum.
5. Spine, from the third plate, of the left anterior interambulacrum.
6. Spine, from the third plate, in the odd anterior ambulacrum.
7. The profile of the same spine as 6.
8. Spine, from the fourth plate of the left anterior ambulacrum.
9. Spine, { upper surface }
10. Spine, { lower surface } from the fourth plate of the odd anterior ambulacrum.
11. Spine, lower surface } at the ambitus.
12. Spine, upper surface } from the fifth plate of the odd anterior ambulacrum.
13. Spine, profile } these larger radioles vary in length from 15 18 mm.
14. Spine, lower surface }
15. Spine, upper surface } from the sixth plate of the odd anterior ambulacrum.
16. Spine, profile }
17. Spine, lower surface } from the seventh plate of the odd anterior ambulacrum.
18. Spine, upper surface }
19. Spine, lower surface }
20. Spine, upper surface } from the eighth plate of the odd anterior ambulacrum.
21. Spine, profile }
22. Spine, lower surface }
23. Spine, top view } from the tenth plate of the left anterior interambulacrum.
24. Spine, profile }
25. Spine, lower surface }
26. Spine, top view } from the eleventh plate of the left anterior interambulacrum.
27. Spine, profile }
28. Spine, lower surface }
29. Spine, top view } from the twelfth plate of the odd anterior ambulacrum.
30. Spine, profile }
31. Spine, lower surface }
32. Spine, upper surface } from the thirteenth plate of the odd anterior ambulacrum.
33. Spine, profile }

The plates from which the spine is taken are counted from the actinal system.

34. Spine, lower surface }
35. Spine, upper surface } from the ocular and genital plates.
36. Spine, profile }

- 37. Spine, lower surface }
 - 38. Spine, upper surface } from the ocular and genital plates.
 - 39. Spine, profile }
- 40. Spine, lower surface }
 - 41. Spine, upper surface } from the ocular and genital plates.
- 42. Spine, side view }
 - 43. Spine, top view } from the ocular and genital plates.
- 44. Spine, lower surface }
 - 45. Spine, top view } from the ocular and genital plates.
- 46. Spine, }
- 47. Spine, } spines, hidden by the big radioles, as seen in fig. 1.
- 48. Spine, }

The figures are about equally magnified except 2, 3, 5, 8, and 46, which are enlargements of adjoining figures in outline. The largest radioles at the ambitus measure 15-18 mm. in length.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899-1900.



PLATE 12.

PLATE 12.

1-6. *Podophora pedifera* Agass.

1. Left anterior interambulacrum.
2. The ninth and tenth interambulacral plates from the actinal system.
3. A tubercle, at the ambitus, from the seventh plate from the actinal system of the left posterior interambulacrum.
4. The same tubercle, seen in profile.
5. Shows a group of miliaries, from the left anterior interambulacrum, abactinal side, eleventh plate from the actinal system.
6. A genital plate and adjoining madreporite from the left anterior interambulacrum.

All the figures are taken from a denuded specimen, measuring 55 mm. in diameter.

Outer reef, Fakarava, Paumotu, "Albatross" Ex., 1899-1900.

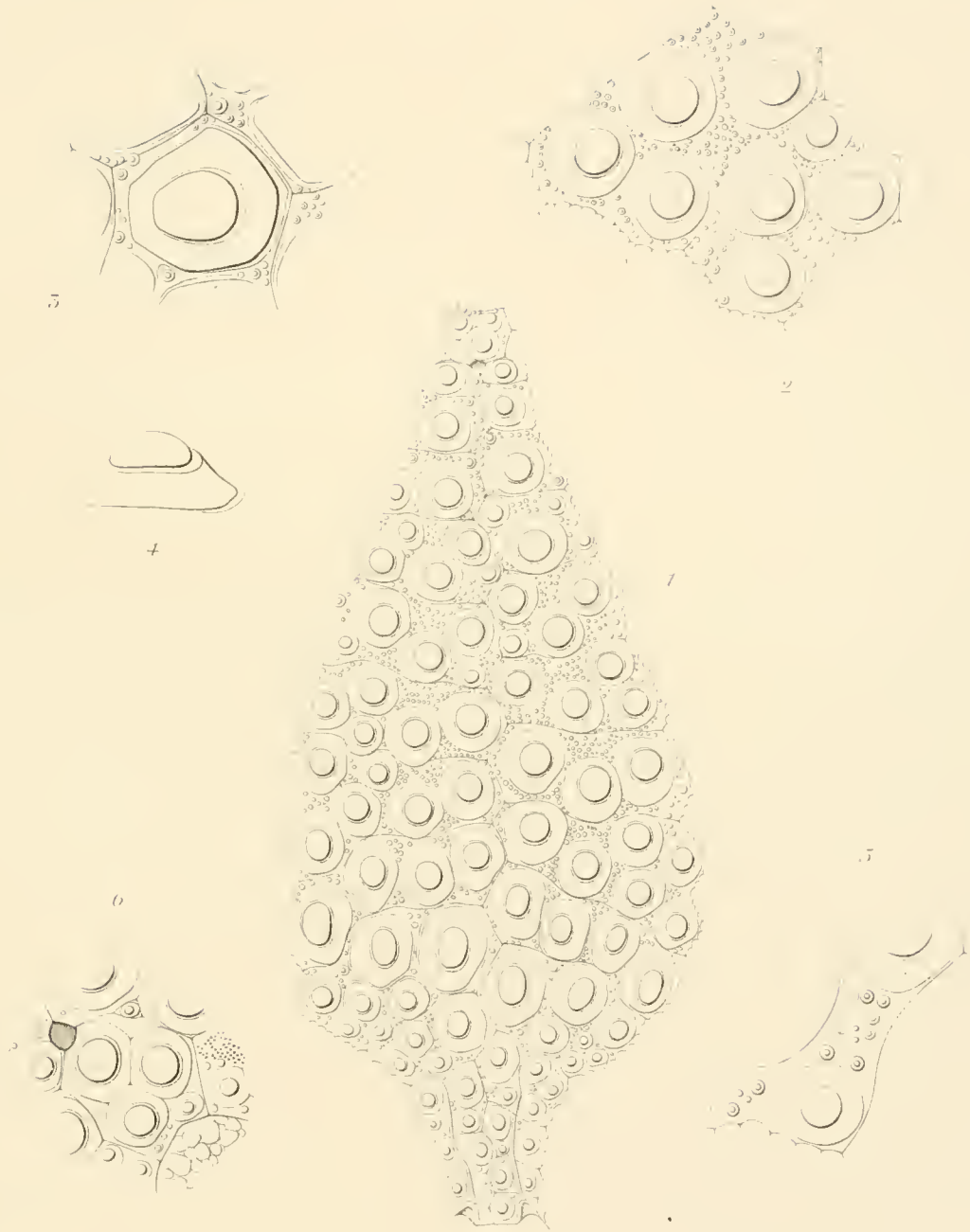


PLATE 13.

PLATE 13.

1-8. *Podophora pedifera* Agass.

1. Interior view of the actinal side, with the lantern in place, odd ambulacrum at the top.
2. A pair of poriferous plates of the buccal membrane, facing the odd anterior ambulacrum.
3. Exterior view of the odd anterior ambulacrum, at edge of the actinal system.
4. The same as 3, seen from the interior.
5. Right posterior ambulacrum, close to the actinal system, showing the sphæridia.
6. Fifth plate from the abactinal system of the odd anterior ambulacrum, abactinal side, exterior view, showing the arrangement of the pores.
7. Same as 6, interior view.
8. Ocular and abactinal ambulacral plates of the left posterior ambulacrum, seen from the interior.

The figures are from same individual: 82 mm. in diameter, including the spines.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899-1900.

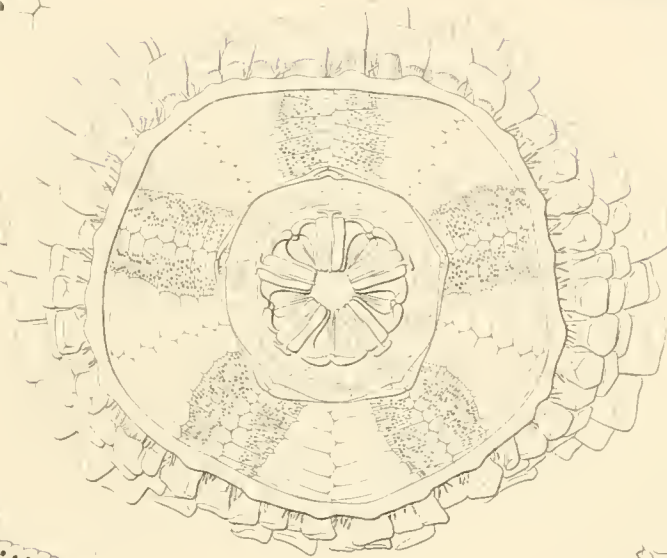
2



7



6



2



5



4

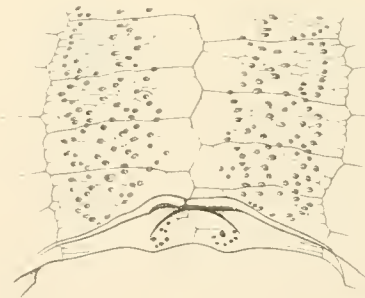
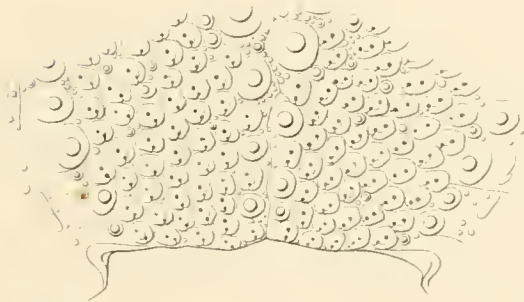


PLATE 14.

PLATE 14.

1-9. *Podophora pedifera* Agass.

1. Abactinal system covered with spines, of a specimen measuring 81 mm. in diameter.
2. Abactinal system of another specimen, 82 mm. in diameter, denuded of its large spines.
3. Exterior view of the abactinal system, denuded, showing the madreporite, genital pores and anal system.
4. The same as 3, seen from the interior.
5. Auricles of the left anterior ambulacrum, seen looking towards the actinostome.
6. Auricles of left anterior ambulacrum, seen from the interior of the test.
7. Odd anterior ambulacrum adjoining the actinal system, seen from the interior, the auricles having been removed.
8. Interior view of the interrarial plates adjoining the actinal system of the right anterior interambulacrum, showing the primordial plate.
9. The same as 8, of the odd posterior interambulacrum.

Figures 2 to 9 are drawn from the same individual, measuring 82 mm. in diameter, including the spines.

Outer reef, Fakarava, Paumotu, "Albatross" Ex., 1899-1900.

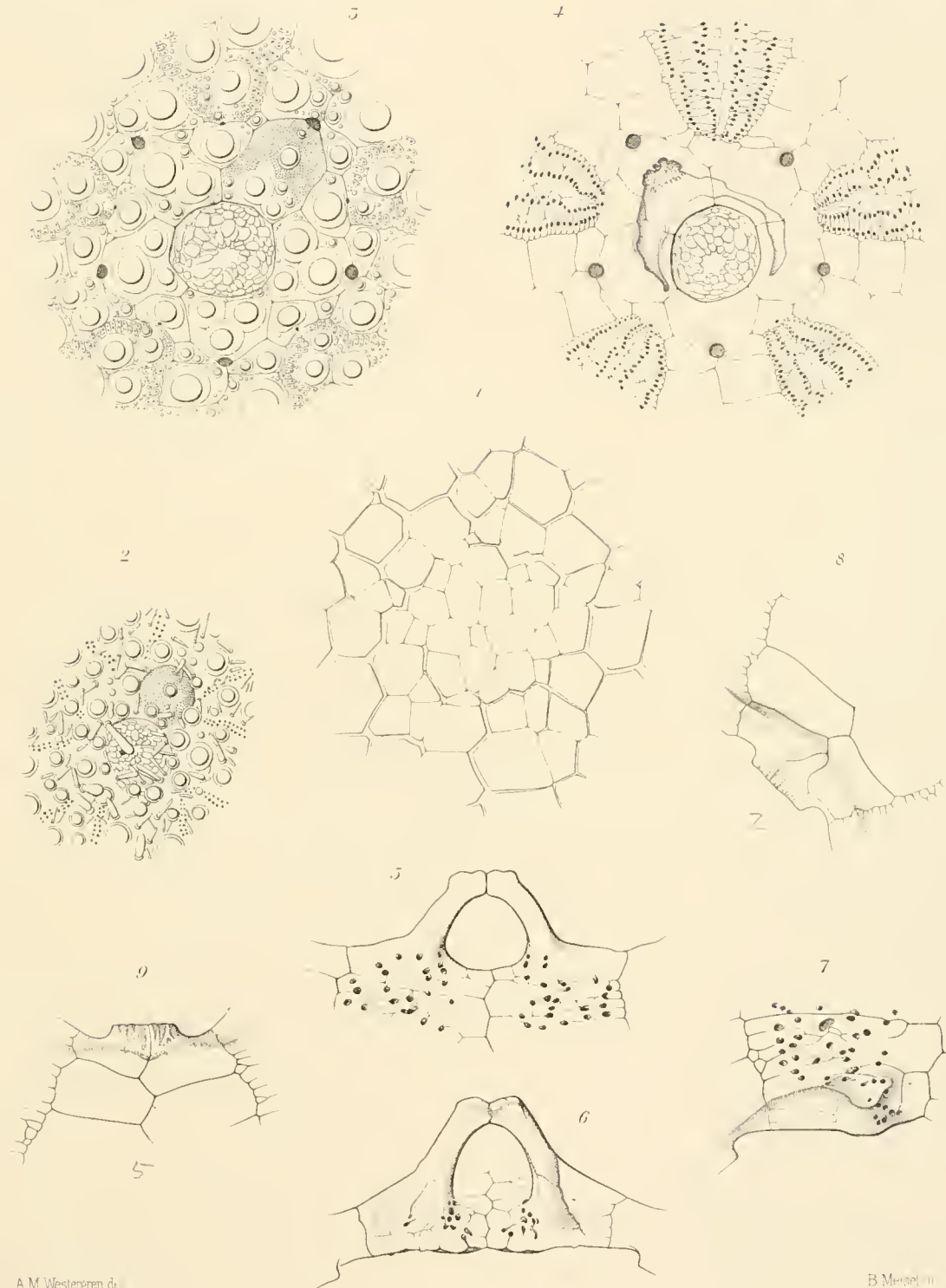


PLATE 15.

PLATE 15.

1-13. *Podophora pedifera* Agass.

1. Lantern seen from above.
2. The same as 1, seen in profile.
3. One of the pyramids seen from the exterior.
4. The same as 3, seen from the interior.
5. The same, seen in profile.
6. The same, seen from above.
7. a. Epiphysis of pyramid, seen from the interior, b. pyramid, in profile, seen from the interior.
8. Detail of the corrugation on the edge of the inside wall of a pyramid.
9. a. Epiphysis of pyramid, seen from the exterior, b. pyramid in profile, seen from the interior.
10. Upper end of a pyramid, exterior view showing a foramen.
11. a. Grooved tooth, b. dorsal view, c. seen in profile.
12. The brace, a. seen from above, b. same in profile, c. from below, d. endwise.
13. Compass, a. seen from above, b. the same in profile.

All the figures from a specimen measuring 82 mm. in diameter, including the spines.
Outer reef, Fakarava, Paumotu, "Albatross" Ex., 1899-1900.

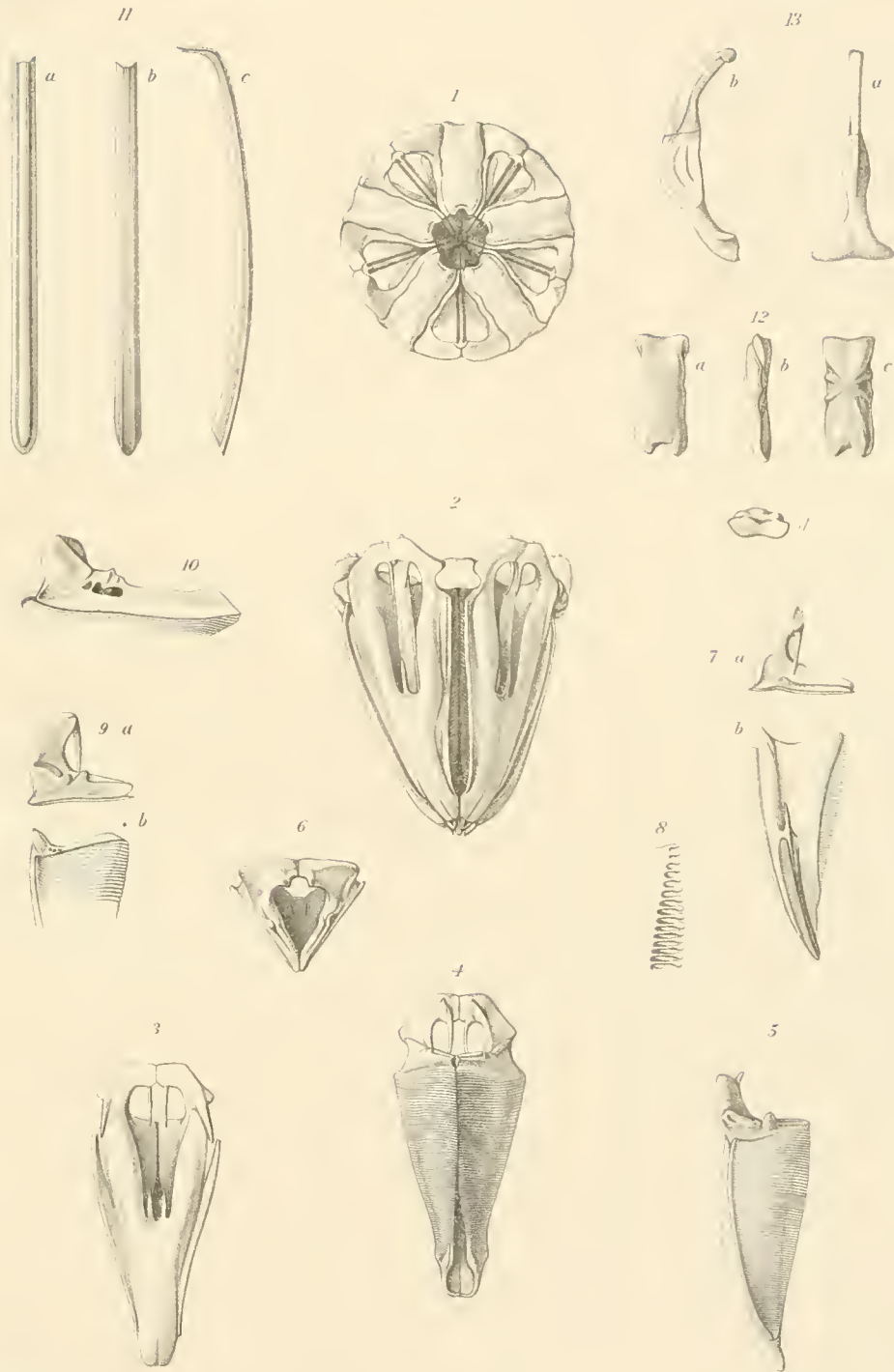


PLATE 16.

PLATE 16.

1-8. *Podophora pedifera* Agass.

1. The disk of an actinal pedicel, seen from above.
2. The same, seen from below.
3. Profile of the same.
4. Disk of an actinal pedicel, oblique view.
5. The disk of an actinal pedicel.
6. Central space of the disk of a pedicel, seen from below with yoke-shaped spicules.
7. Basal part of one of the laminæ.
8. Spicule.

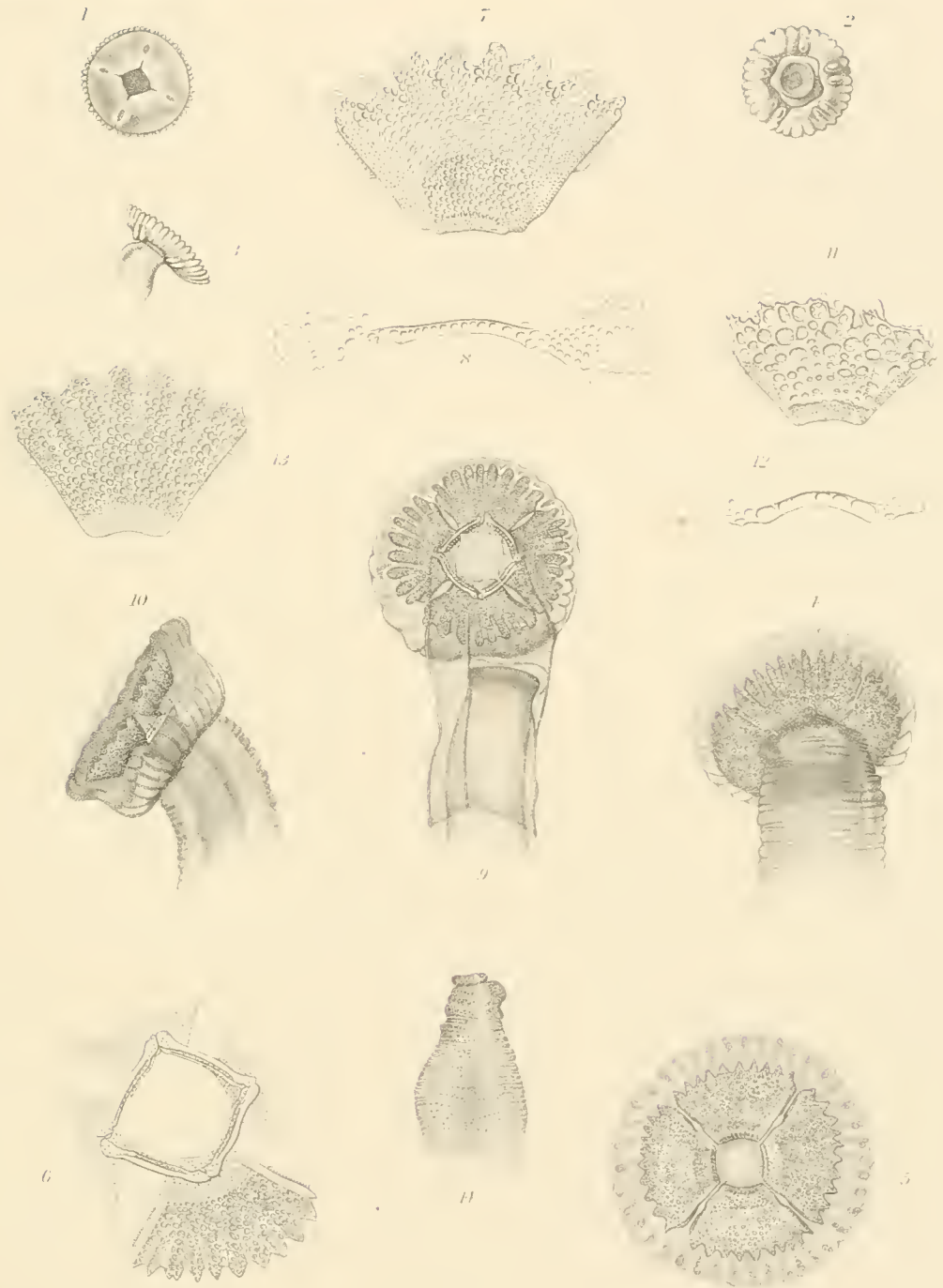
9-14. *Podophora atrata* Agass.

9. An actinal pedicel, seen from below the disk.
10. Actinal pedicel seen in profile.
11. Basal part of one of the laminæ of the disk, from a specimen of 8 mm. in diameter.
12. Yoke-shaped spicule from the same specimen as 11.
13. Basal part of one of the laminæ of the disk.
14. The tip of a dorsal pedicel.

The figures 1 to 8 are from a specimen of 82 mm. in diameter including the spines. With the exception of 11, 12, the others are drawn from a specimen measuring 74 mm. in diameter, including the spines.

Podophora pedifera from the outside reef, Fakarava, Paumotus, "Albatross" Ex., 1899-1900.

P. atrata from the Hawaiian Ids., A. Garrett Coll.



- | | | |
|------------------------------------|---|---|
| 1. A valve 0.23 mm. | } | Ophicephalous pedicellaria, from the buccal membrane close to the teeth. |
| 2. A valve 0.19 mm. | | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, interior view. |
| 3. A valve 0.22 mm. | | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, profile. |
| 4. A valve 0.22 mm. | | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, detail of articulation, exterior view. |
| 5. A valve 0.23 mm. | | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, detail of articulation, exterior view. |
| Valves from the same pedicellaria. | | |
| 6. A valve 0.40 mm. | } | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, interior view. |
| 7. A valve 0.32 mm. | | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, interior view. |
| 8. A valve 0.40 mm. | } | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, magnified base of fig. 6. |
| 9. A valve 0.36 mm. | | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, magnified base of fig. 7. |
| 10. A valve 0.32 mm. | | Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, magnified base of fig. 7. |
| 11. A valve 0.47 mm. | | Tridentate pedicellaria, from the actinal side of the left anterior ambulaeum. |
| 12. A valve 0.44 mm. | | Tridentate pedicellaria, interior view from the right anterior ambulaeum. |
| 13. A valve 0.47 mm. | } | Tridentate pedicellaria, exterior view, profile, from the right anterior ambulaeum. |
| 14. A valve 0.47 mm. | | Tridentate pedicellaria, interior view, profile, from the right anterior ambulaeum. |
| From the same pedicellaria. | | |
| 15. A valve 0.26 mm. | } | Ophicephalous pedicellaria, near the ambitus from the actinal side of the right posterior interambulaeum. |
| 16. A valve 0.26 mm. | | Ophicephalous pedicellaria, serration of edge, same pedicellaria as 15. |
| 17. A valve 0.24 mm. | | Ophicephalous pedicellaria, interior view from the abactinal side of the right posterior interambulaeum. |
| 18. A valve 0.11 mm. | } | Globiferous pedicellaria, exterior view from the abactinal side of the left posterior ambulaeum. |
| 19. A valve 0.11 mm. | | Globiferous pedicellaria, profile, same pedicellaria as 18. |

Figures 1-5 are the same pedicellaria, from a specimen 8 mm. in diameter ; 6-10, from a specimen 74 mm. in diameter ; and 11-19 from a specimen 8 mm. in diameter, including the spines.

The measurements give the natural size. The enlargement of the figures is about the same, excepting 6, 7, and 8, 9, 10, which are somewhat larger.

Hawaiian Ids., A. Garrett, Coll.

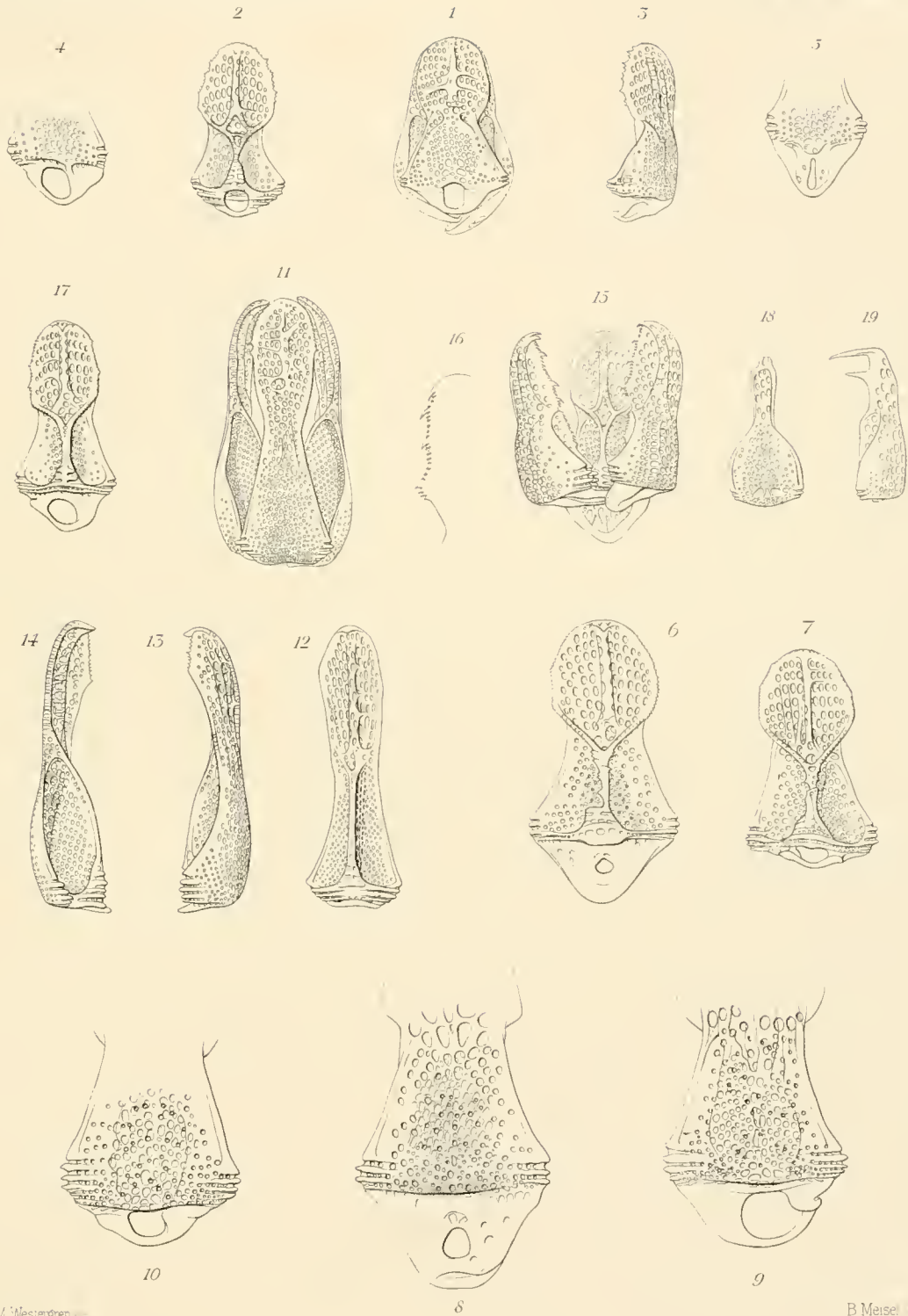


PLATE 18.

PLATE 18.

1-18. *Podophora atrata* Agass.

1-18. Valves of pedicellariæ.

- | | | |
|----------------------|---|--|
| 1. A valve 0.67 mm. | } | Tridentate pedicellaria, from the buccal membrane close to the teeth, exterior view. |
| 2. A valve 0.65 mm. | | Tridentate pedicellaria, from the buccal membrane close to the teeth, exterior view. |
| 3. A valve 0.63 mm. | | Tridentate pedicellaria, from the buccal membrane close to the teeth, interior view |
| 4. A valve 0.85 mm. | } | Tridentate pedicellaria, from the left anterior ambulacrum, not far from actinal system, exterior view. |
| 5. A valve 0.88 mm. | | Tridentate pedicellaria, from the left anterior ambulacrum, interior view. |
| 6. A valve 0.87 mm. | } | Tridentate pedicellaria, from the left anterior ambulacrum, interior view profile. |
| 7. A valve 0.57 mm. | | Ophicephalous pedicellaria from the right anterior ambulacrum 1, midway between the actinal system and the ambitus, interior view. |
| 8. A valve 0.50 mm. | } | Ophicephalous pedicellaria, same pedicellaria as 7, interior view. |
| 9. A valve 0.48 mm. | | Ophicephalous pedicellaria, same pedicellaria as 7, interior view. |
| 10. A valve 0.15 mm. | } | Triphyllous pedicellaria, from the odd anterior ambulacrum among the sphæridia, exterior view. |
| 11. A valve 0.15 mm. | | Triphyllous pedicellaria, same pedicellaria as 10, interior view. |
| 12. A valve 0.16 mm. | | Triphyllous pedicellaria, same pedicellaria as 10, exterior view, profile. |
| 13. A valve 0.49 mm. | } | Tridentate pedicellaria, from the actinal side of the left anterior interambulacrum, near the ambitus, exterior view. |
| 14. A valve 0.47 mm. | | Tridentate pedicellaria, same as 13, interior view. |
| 15. A valve 0.48 mm. | } | Tridentate pedicellaria, same as 13, exterior view, profile. |
| 16. A valve 0.39 mm. | | Tridentate pedicellaria, from the right anterior ambulacrum, midway between the ambitus and the abactinal system, interior view. |
| 17. A valve 0.24 mm. | } | Globiferous pedicellaria from the odd anterior ambulacrum near the ocular plate, interior view. |
| 18. A valve 0.21 mm. | | Globiferous pedicellaria, same as 17, exterior view, profile. |

The valves are taken from the same specimen, measuring 74 mm. in diameter, including the spines.

The measurement of the figures gives the natural size; the enlargement of the valves of each pedicellaria is the same, but the enlargement of the different pedicellariæ is not identical.

Hawaiian Ids., A. Garrett Coll.

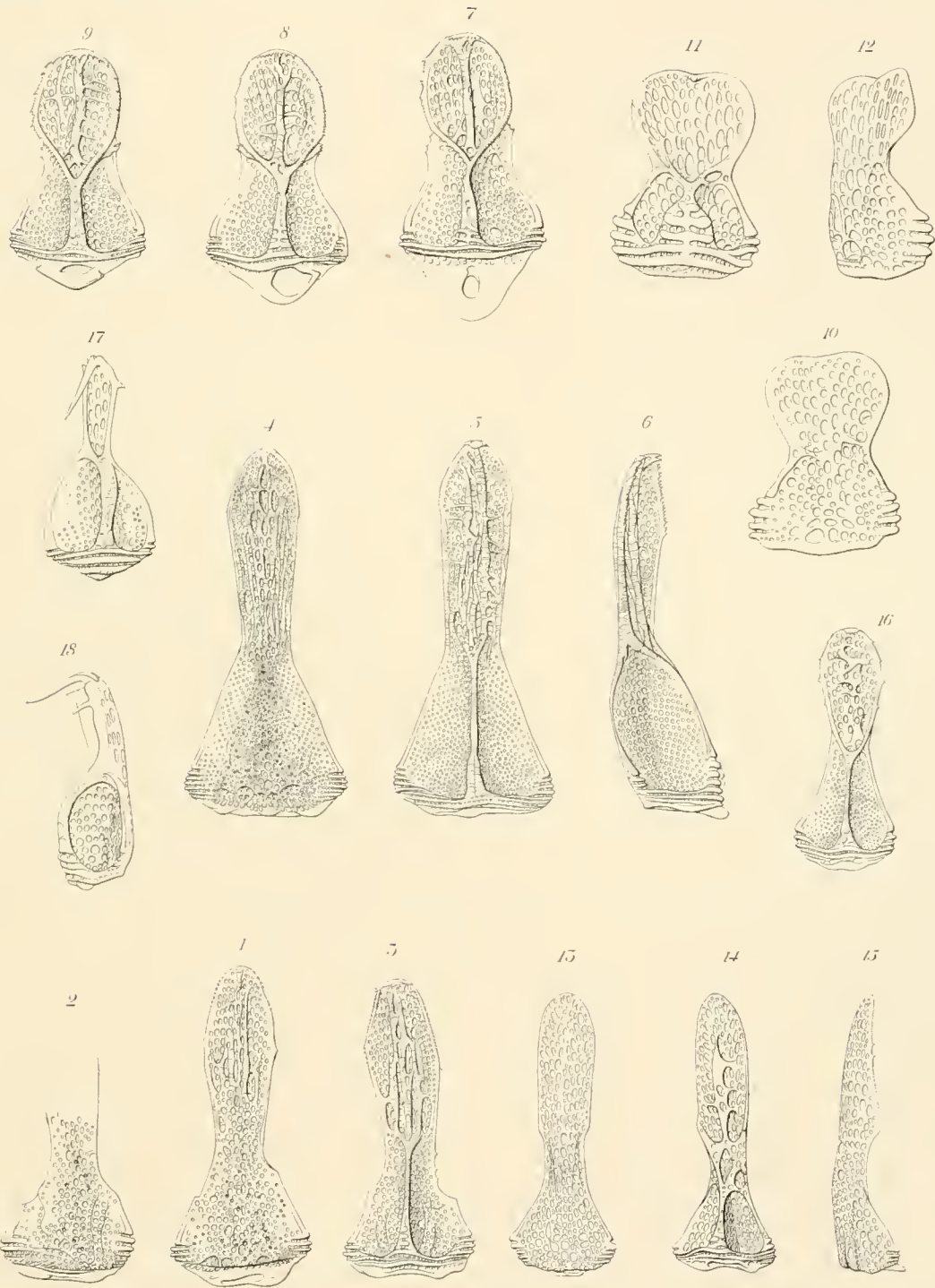


PLATE 19.

PLATE 19.

1-16. *Podophora atrata* Agass.

1-16. Valves of pedicellariæ.

1. A valve 0.53 mm. Tridentate pedicellaria, exterior view, near the actinal system, from the right posterior ambulacrum of a specimen 18 mm. in diameter, including the spines.
2. A valve 0.55 mm. Tridentate pedicellaria, near the actinal system, from the left posterior ambulacrum, same specimen as 1.
3. A valve 0.71 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the right anterior ambulacrum of a specimen 35 mm. in diameter, including the spines.
4. A valve 0.66 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the odd anterior ambulacrum, same specimen as 3.
5. A valve 0.84 mm. Tridentate pedicellaria, at the ambitus, from the left anterior ambulacrum, same as 3.
6. A valve 0.83 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the odd posterior interambulacrum, same as 3.
7. A valve 0.81 mm. Tridentate pedicellaria, near the actinal system, from the right posterior ambulacrum of a specimen 67 mm. in diameter, including the spines.
8. A valve 0.85 mm. Tridentate pedicellaria, near the actinal system, from the left anterior ambulacrum, same specimen as 7.
9. A valve 0.90 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the left posterior ambulacrum, same as 7.
10. A valve 0.82 mm. Tridentate pedicellaria, at the ambitus, from the right posterior ambulacrum, same as 7.
11. A valve 0.47 mm. Tridentate pedicellaria, midway between the ambitus and the abactinal system, from the left anterior ambulacrum, same as 7.
12. A valve 0.74 mm. Tridentate pedicellaria, on the actinal side of the ambitus, from the right posterior ambulacrum, same as 7.
13. A valve 0.41 mm. Tridentate pedicellaria, near the ocular plate, from the left anterior ambulacrum, same as 7.
14. A valve 0.14 mm. Triphyllous pedicellaria, near the actinal system, from the left anterior ambulacrum, same as 7.
15. A valve 0.12 mm. Triphyllous pedicellaria, from the abactinal side of the ambitus, from the right posterior ambulacrum, same as 7.
16. A valve 0.11 mm. Triphyllous pedicellaria, near the apical system, from the left anterior ambulacrum, same as 7.

The same valve in each pedicellaria is figured. The enlargement of the figures is about the same. All the figures present an exterior view.

Hawaiian Ids., A. Garrett Coll.

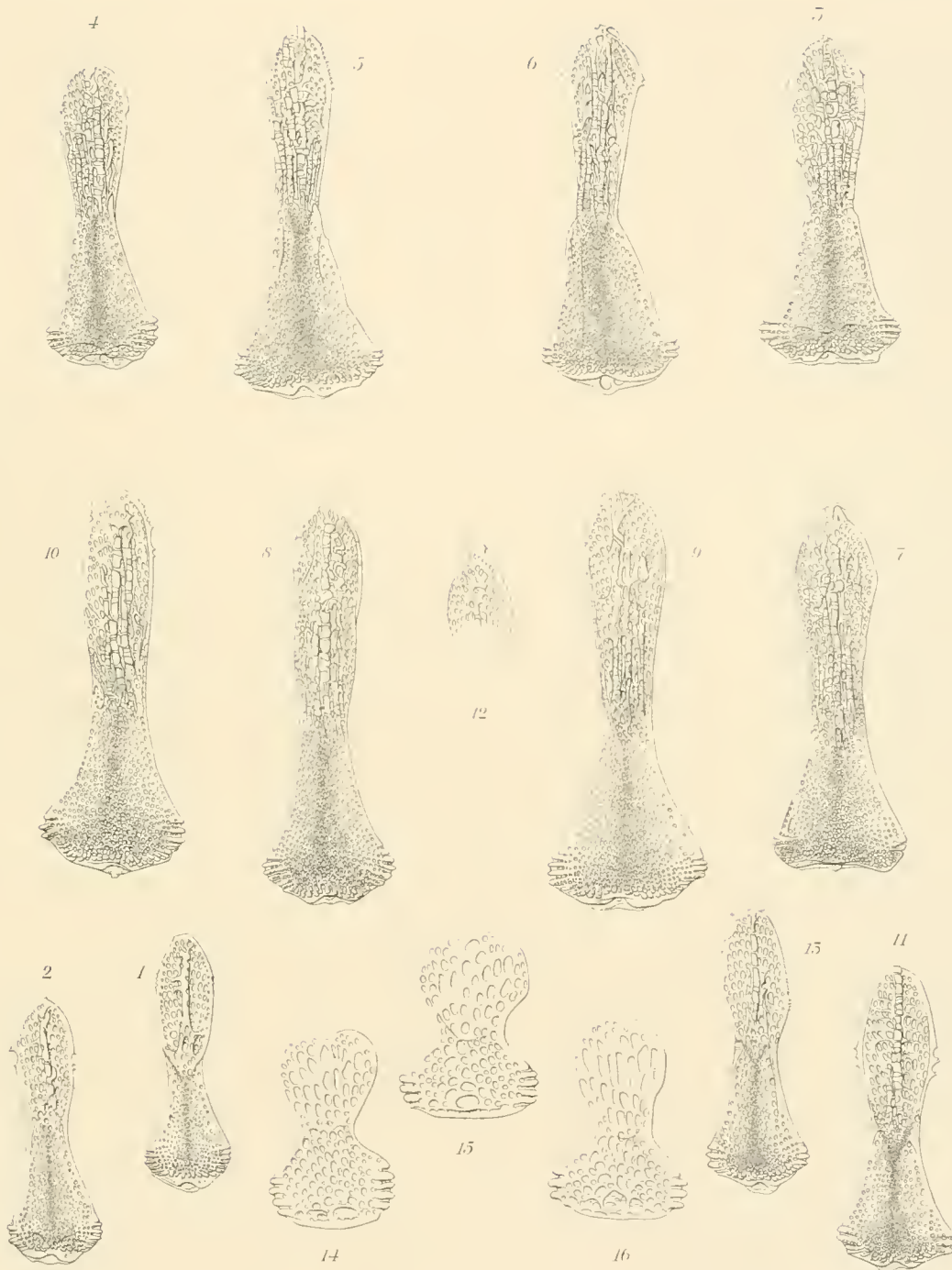


PLATE 20.

PLATE 20.

1-6. *Podophora atrata* Agass.

1. Seen from actinal side.
2. The same as 1 seen from actinal side denuded of its spines.
3. The same seen from the abactinal side.
4. Seen from the abactinal side, denuded of its spines.
5. Seen in profile facing the odd posterior interambulacrum.
6. The same denuded, facing the odd anterior ambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figs. 1, 2, 3, and 4.

All figures are natural size.

Hawaiian Ids., A. Garrett Coll.

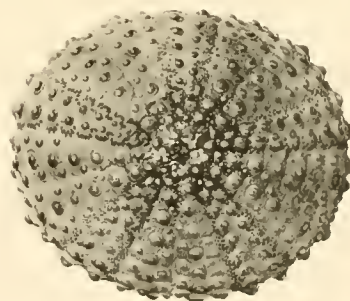
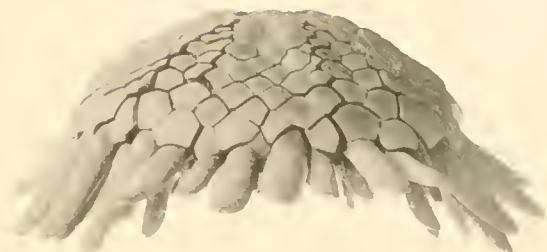
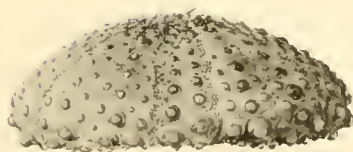
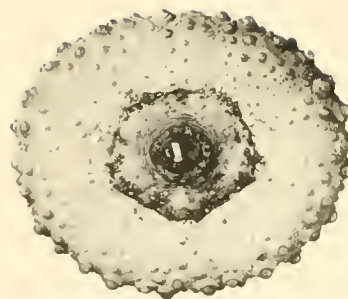
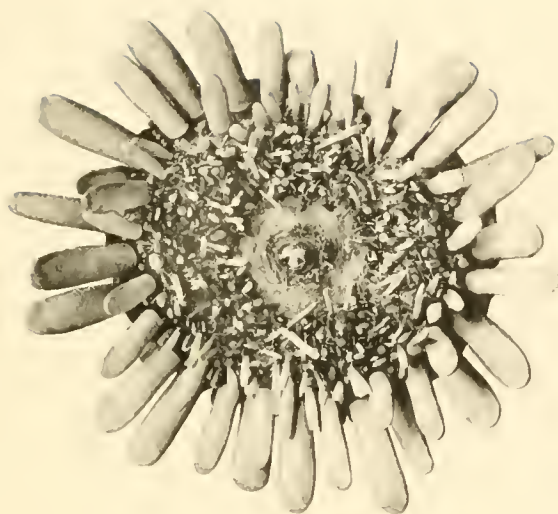


PLATE 21.

PLATE 21.

1-6. *Podophora atrata* Agass.

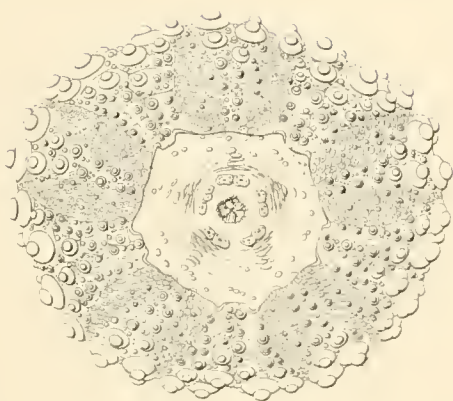
1. Denuded test, seen from the actinal side.
2. The same seen from the abactinal side.
3. Seen in profile facing the odd anterior ambulacrum.
4. Seen from the actinal side.
5. The same seen from the abactinal side.
6. Profile of the same, facing the odd posterior interambulacrum.

All figures are natural size.

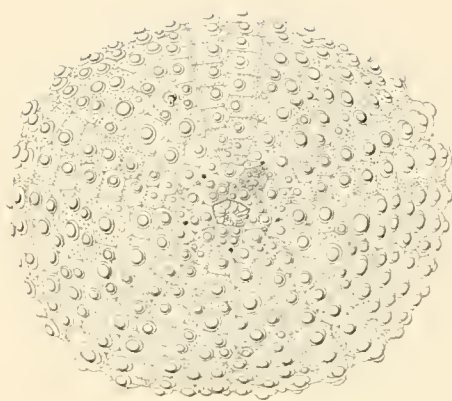
The odd anterior ambulacrum occupies the center of the upper part of figures 1, 2, 4, 5.

Hawaiian Ids., A. Garrett coll.

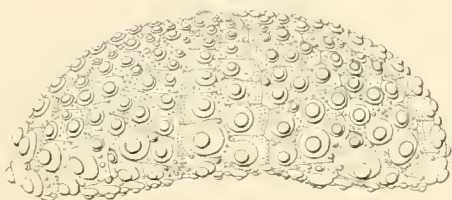
1



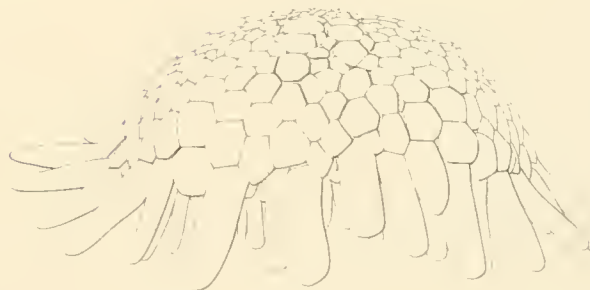
2



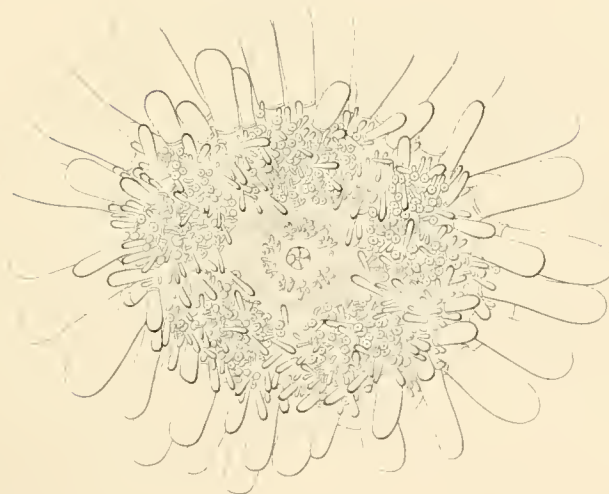
3



6



4



5

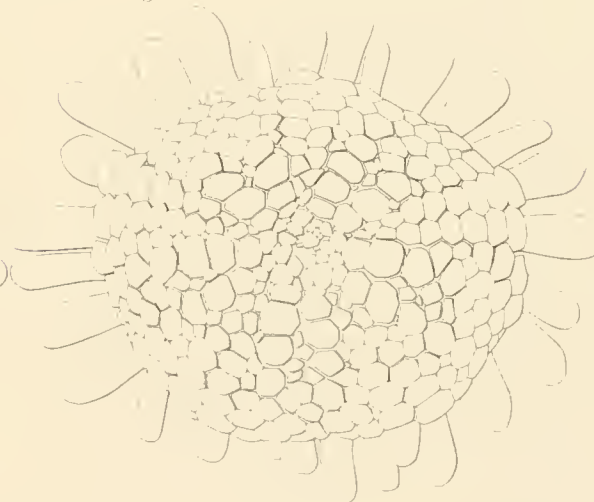


PLATE 21a.

PLATE 21a.

1-3. *Podophora atrata* Agass.

1. Specimen with club-shaped primary radioles, seen from the actinal side.
2. The same as fig. 1, seen from the abactinal side.
3. The same seen in profile facing the odd posterior interambulacrum.

The odd anterior ambulacrum is at the top of figures 1 and 2.

This specimen measures 92 mm., and was collected at Mauritius.

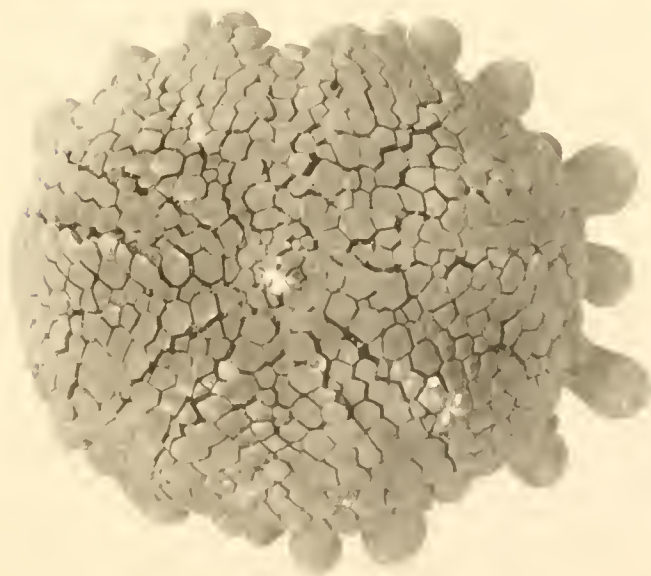
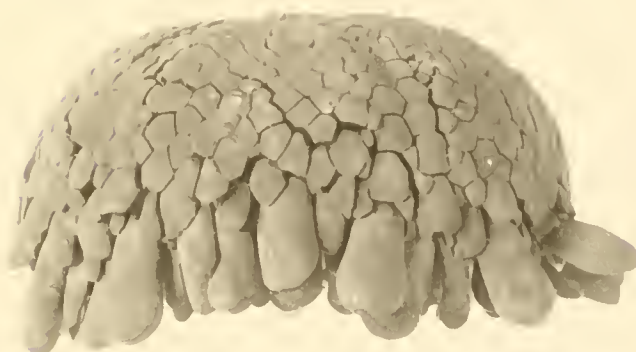
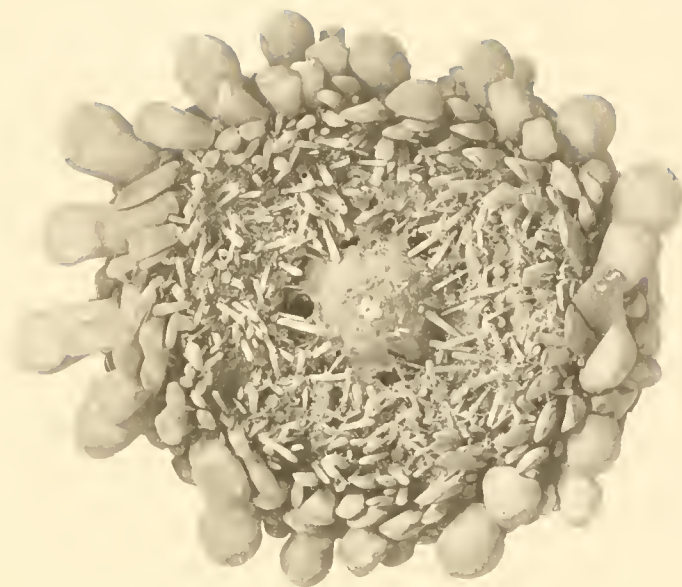


PLATE 21b.

PLATE 21b.

1-3. *Podophora atrata* Agass.

1. Test seen from the actinal side.
2. The same seen from the abactinal side.
3. The same in profile facing the odd interambulacrum.

This specimen measures 97 mm. including the spines, collected at Mauritius by Nicolas Pike.

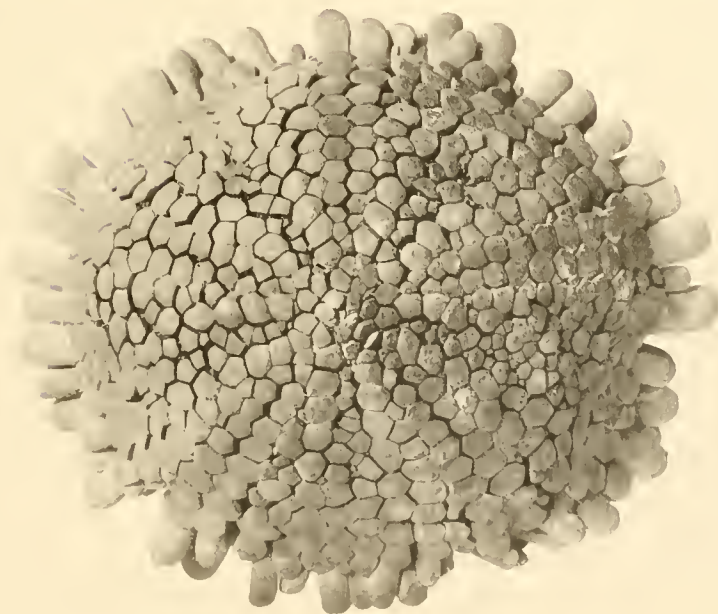
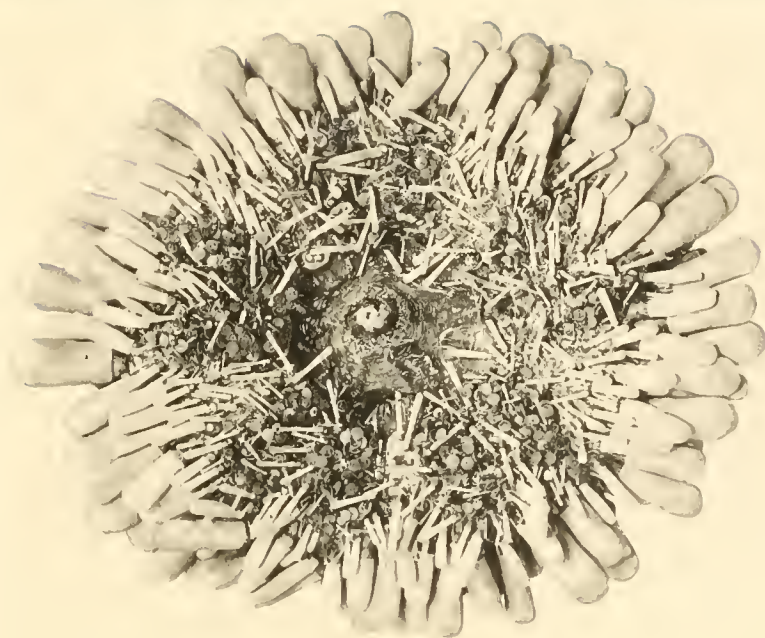


PLATE 22.

PLATE 22.

1-10. *Podophora atrata* Agass.

1. From a specimen 12 mm. in diameter, including the spines.
2. From a specimen 14 mm. in diameter, including the spines.
3. From a specimen 18 mm. in diameter, including the spines.
4. From a specimen 26 mm. in diameter, including the spines.
5. From a specimen 31 mm. in diameter, including the spines.
6. From a specimen 35 mm. in diameter, including the spines.
7. From a specimen 46 mm. in diameter, including the spines.
8. From a specimen 67 mm. in diameter, including the spines.
9. From a specimen 74 mm. in diameter, including the spines.
10. From a specimen 77 mm. in diameter, including the spines.

The figures show the order of growth of the spines; the same view is given for each specimen, showing the left posterior ambulacrum, the odd posterior interambulacrum in the center, and one half of the right posterior ambulacrum.

The dotted lines join the radioles of the same vertical row.

Hawaiian Ids., A. Garrett Coll.

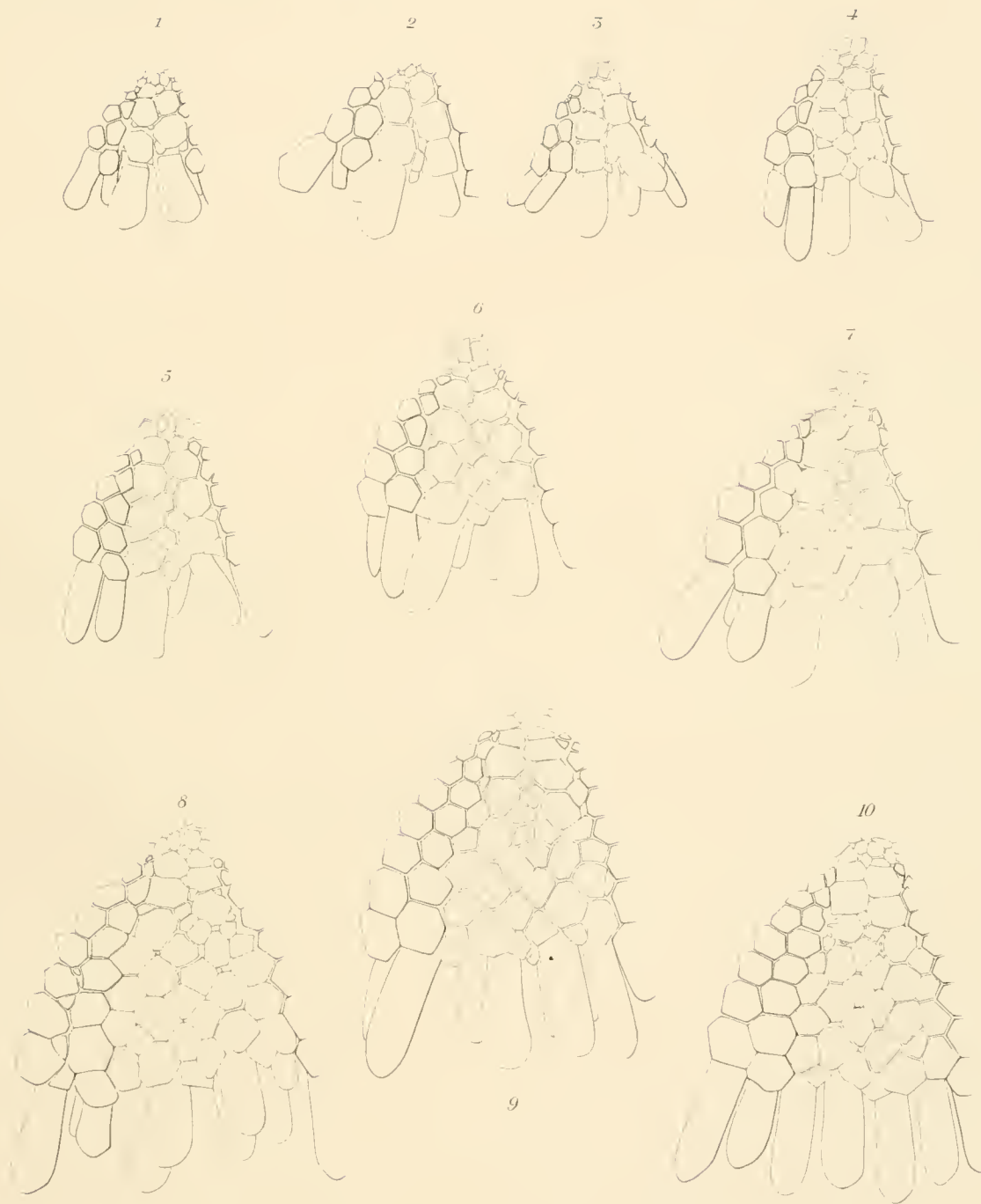


PLATE 23.

1-33. *Podophora atrata* Agass.

1-33 Spines.

1. Spine, from the actinal system near the teeth.
 2. Spine, near the actinal system, from the odd anterior ambulacrum.
 3. Spine, } lower surface, near the actinal system, from the left anterior interambulacrum.
 4. Spine, } upper surface, near the actinal system, from the left anterior interambulacrum.
 5. Spine, } profile, near the actinal system, from the left anterior interambulacrum.
 6. Spine, } upper surface, from the actinal side of the ambitus, from the left posterior interambulacrum.
 7. Spine, } lower surface, from the actinal side of the ambitus, from the left posterior interambulacrum.
 8. Spine, } profile, from the actinal side of the ambitus, from the left posterior interambulacrum.
 9. Spine, } upper surface, at the ambitus, from the right anterior ambulacrum.
 10. Spine, } lower surface, at the ambitus, from the right anterior ambulacrum.
 11. Spine, } profile, at the ambitus, from the right anterior ambulacrum.
- These larger radioles vary in length from 15-20 mm.
12. Spine, } upper surface, at the ambitus, from the left posterior interambulacrum.
 13. Spine, } lower surface, at the ambitus, from the left posterior interambulacrum.
 14. Spine, } profile, at the ambitus, from the left posterior interambulacrum.
 15. Spine, } lower surface, from the abactinal side, near the ambitus, from the right posterior ambulacrum.
 16. Spine, } top view, from the abactinal side, near the ambitus, from the right posterior ambulacrum.
 17. Spine, } profile, from the abactinal side, near the ambitus, from the right posterior ambulacrum.
 18. Spine, } upper surface, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
 19. Spine, } lower surface, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
 20. Spine, } profile, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
 21. Spine, } lower surface, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
 22. Spine, } top view, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
 23. Spine, } profile, from the abactinal side, near the ambitus, from the right anterior interambulacrum.

24. Spine, } side view, from the abactinal side, near the ambitus, from the right posterior interambulacrum.
25. Spine, } profile, from the abactinal side, near the ambitus, from the right posterior interambulacrum.
26. Spine, } lower side, midway between the ambitus and the abactinal side, from the right posterior interambulacrum.
27. Spine, } profile, midway between the ambitus and the abactinal side, from the right posterior interambulacrum.
28. Spine, } top view, midway between the ambitus and the abactinal side, from the right posterior interambulacrum.
29. Spine, } lower surface, from the genital plates.
30. Spine, } profile, from the genital plates.
31. Spine, } top view, from the genital plates.
32. Spine, side view, from the madreporic plate.
33. Spine, from the abactinal side of the right posterior interambulacrum. These spines are hidden under the big primary radioles (see Pl. **11**, fig. 1).

The enlargement of the figures is about the same. The shaded figs. 1, 2, and 33 are drawn on a larger scale.

Hawaiian Ids., A. Garrett Coll.



PLATE 24.

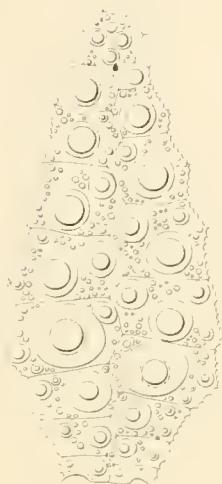
PLATE 24.

1-8. *Podophora atrata* Agass.

1. Left anterior interambulacrum of a denuded specimen measuring 8 mm. in diameter.
2. The same interambulacrum from a denuded specimen 14 mm. in diameter.
3. The same interambulacrum from a denuded specimen 26 mm. in diameter.
4. The same interambulacrum from a denuded specimen 45 mm. in diameter.
5. A primary tubercle at the ambitus, on the fifth plate from the actinal system, the denuded test measuring 45 mm. in diameter.
6. The same, tubercle in profile.
7. The genital and last interambulacral plates, the seventh and eighth from the actinal system in the left anterior interambulacrum, of a denuded specimen, measuring 8 mm. in diameter.
8. The ninth and tenth plates of the left anterior interambulacrum, of a denuded test measuring 45 mm. in diameter.

Hawaiian Ids., A. Garrett Coll.

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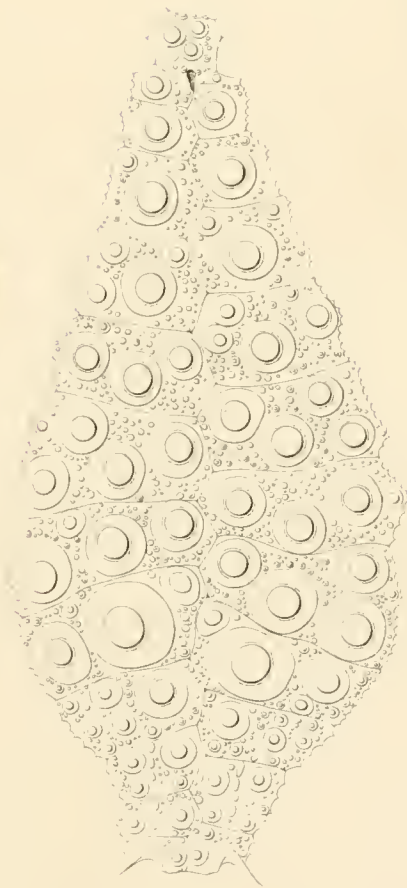


PLATE 25.

PLATE 25.

1-10. *Podophora atrata* Agass.

1. Seen from abactinal side, with spines, measuring 14 mm. in diameter.
2. The same, denuded, seen from the actinal side, measuring 8 mm. in diameter.
3. The same seen from the abactinal side.
4. Profile of the same, facing the bivium and the odd posterior interambulacrum.
5. Interior view of the test of the same showing the abactinal system.
6. Left posterior ambulacral plates adjoining the actinal system.
7. Odd anterior ambulacrum at the ambitus.
8. Part of the abactinal system, the left anterior interambulacral and genital plates.
9. The odd anterior ambulacral plates adjoining the actinal system, of a denuded specimen measuring 45 mm. in diameter.
10. The same ambulacrum, partly on the actinal, and partly on the abactinal side of the ambitus.

Figures 1 to 8 are drawn from the same denuded specimen, measuring 8 mm. in diameter.
Hawaiian Ids., A. Garrett Coll.

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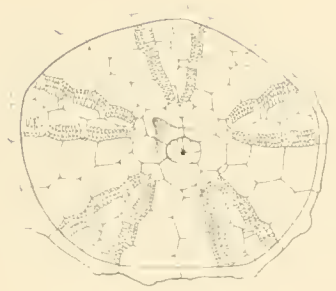
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PLATE 26.

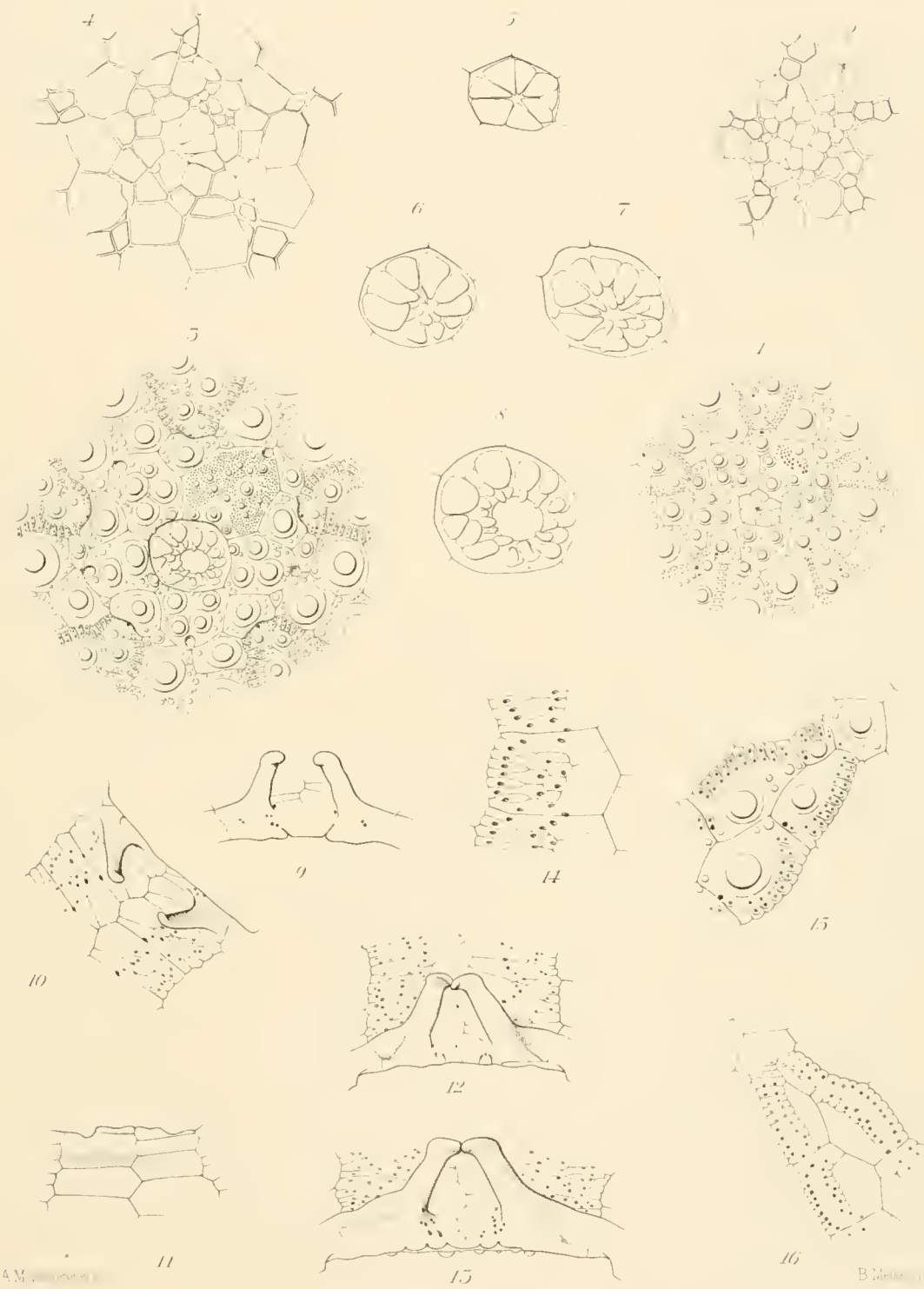
PLATE 26.

1-16. *Podophora atrata* Agass.

1. Abactinal system, denuded of spines, of a specimen measuring 8 mm. in diameter.
2. The same, measuring with spines 14 mm. in diameter.
3. Abactinal system of a specimen measuring with spines 74 mm. in diameter, and denuded 45 mm.
4. Abactinal system, covered with spines, of a specimen measuring 77 mm. in diameter.
5. Anal system of a specimen 8 mm. in diameter.
6. Anal system of a specimen 14 mm. in diameter.
7. Anal system of a specimen 26 mm. in diameter.
8. Anal system of a specimen 45 mm. in diameter.
9. The auricles of the right anterior ambulacrum, seen from the interior of the test of a specimen 8 mm. in diameter.
10. The auricles of the left posterior ambulacrum, looking towards the actinostome, same specimen as 9.
11. Actinal part of the odd posterior interambulacrum, interior view of a specimen 8 mm. in diameter.
12. Auricles of the odd anterior ambulacrum, seen from the interior of the test of a specimen 14 mm. in diameter.
13. The same ambulacrum as 12 from a specimen 45 mm. in diameter.
14. Part of the odd anterior ambulacrum, seen from the interior.
15. Exterior view of the ocular and ambulacral plates of the left posterior ambulacrum of a specimen 8 mm. in diameter.
16. The same seen from the interior.

Figures 1, 5, 9-11, 15 and 16, are drawn from the same individual.

Hawaiian Ids., A. Garrett Coll.



A.M.

B.M.

PLATE 27.

PLATE 27.

1-14. *Podophora atrata* Agass.

1. Lantern seen from above.
 2. The same as 1, seen in profile.
 3. One of the pyramids, seen from the exterior.
 4. The same as 3, seen from the interior.
 5. The same seen in profile.
 6. The same seen from above.
 7. Pyramid, in profile, from the interior.
 8. a. Epiphysis of pyramid, from the outside, b. top of a pyramid, in profile.
 9. A tooth still in its socket.
 10. a. Groove of tooth ; b. dorsal view of tooth, c. seen in profile.
 11. Part of 10 c. enlarged.
 12. Upper part of tooth.
 13. a. The brace, seen from above, b. seen in profile, c. from below, d. endwise.
 14. a. Compass seen from above, b. the same in profile.
- All the figures are taken from a denuded specimen measuring 8 mm. in diameter.
Hawaiian Ids., A. Garrett Coll.

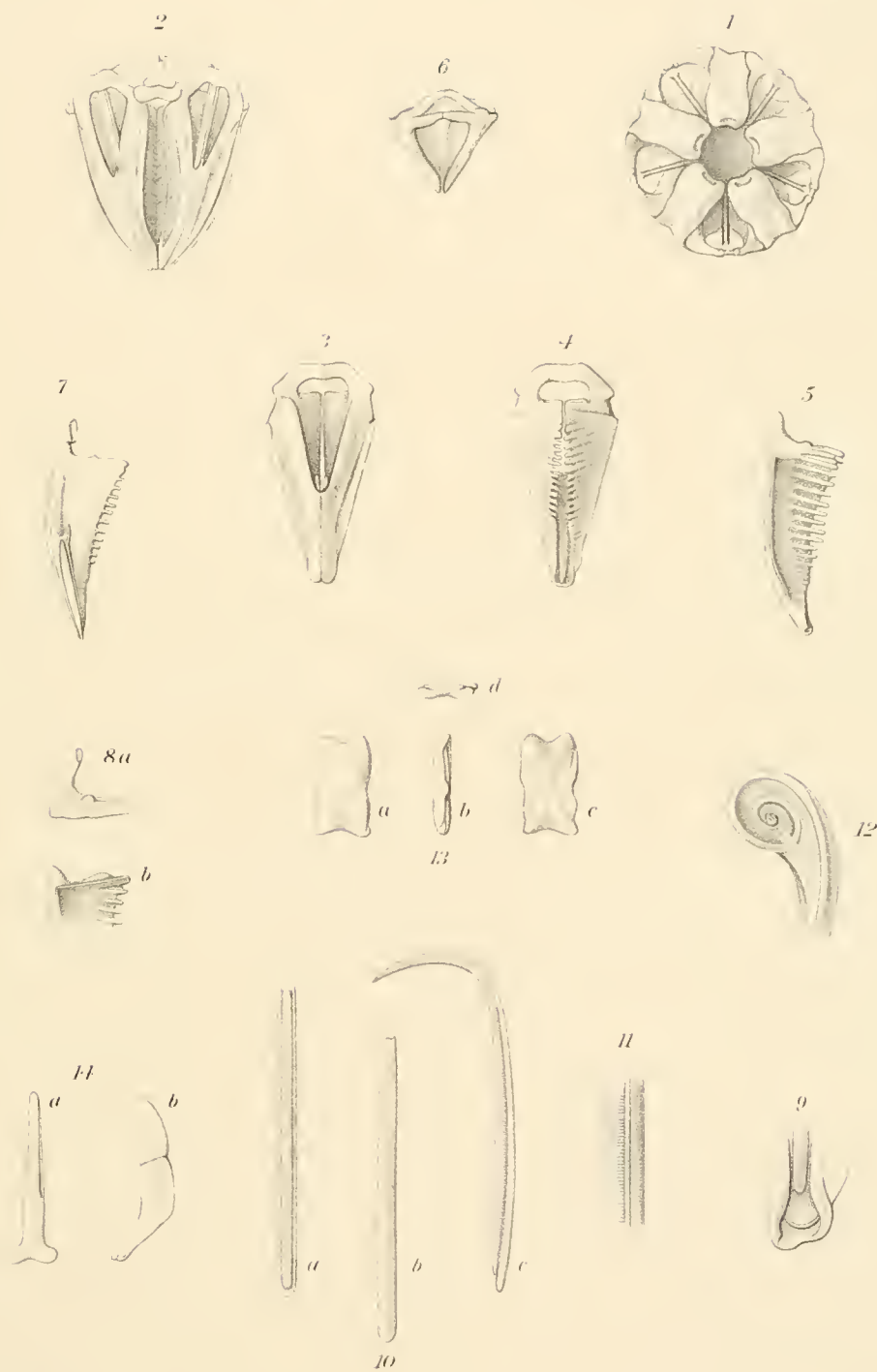


PLATE 28.

PLATE 28.

1-11. *Podophora atrata* Agass.

1. Lantern, seen from above.
2. The same as 1, seen in profile.
3. One of the pyramids, seen from the exterior.
4. The same seen from the interior.
5. The same seen in profile.
6. Same seen from above.
7. a. Epiphysis of pyramid seen from the inside, b. pyramid seen in profile from the interior.
8. a. Epiphysis of pyramid from the exterior, b. upper end of a pyramid seen from the exterior.
9. a. Groove of tooth, b. dorsal view of tooth, c. seen in profile.
10. a. The brace, seen from above, b. seen in profile, c. from below, d. endwise.
11. a. Compass seen from above, b. the same in profile.

The figures are drawn from a denuded specimen 45 mm. in diameter.

Hawaiian Ids., A. Garrett Coll.

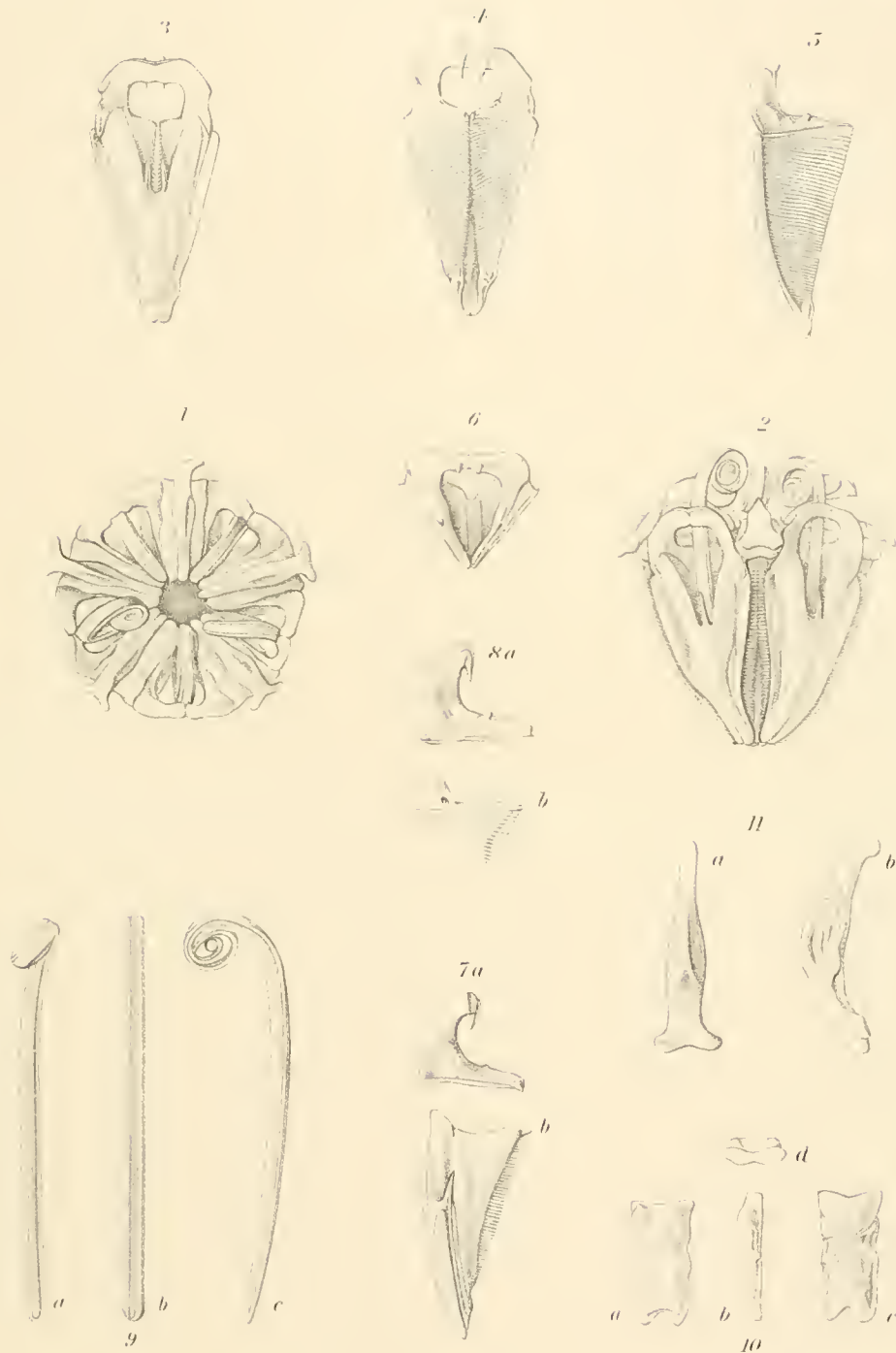


PLATE 29.

PLATE 29.

1-17. *Colobocentrotus Stimpsoni* A. Ag.

1-17. Valves of pedicellariæ.

1. A valve 0.41 mm. of an Ophicephalous pedicellaria, exterior view, near the teeth.
2. A valve 0.36 mm. } Ophicephalous pedicellaria, interior view, near the teeth.
3. A valve 0.48 mm. } Ophicephalous pedicellaria, exterior view, nearer the actinal system
than the ambitus, from the odd anterior ambulacrum.
4. A valve 0.50 mm. Ophicephalous pedicellaria profile, interior view, nearer the actinal
system than the ambitus, from the right anterior ambulacrum.
5. A valve 0.51 mm. Ophicephalous pedicellaria, interior view.
6. A valve 0.51 mm. Ophicephalous pedicellaria, midway between the actinal system
and the ambitus, from the left anterior ambulacrum.
7. A valve 0.88 mm. } Tridentate pedicellaria, exterior view, not far from the actinal
system, from the left posterior ambulacrum.
8. A valve 0.78 mm. } Tridentate pedicellaria, interior view.
9. A valve 0.86 mm. } Tridentate pedicellaria, profile, exterior view.
10. A valve 0.47 mm. Ophicephalous pedicellaria, showing the articulation near the am-
bitus, from the left anterior interambulacrum.
11. A valve 0.47 mm. Ophicephalous pedicellaria, interior view, nearer the ambitus than
the actinal system, from the right anterior interambulacrum.
12. A valve 0.47 mm. Ophicephalous pedicellaria, interior view near the ambitus, from
the right anterior interambulacrum.
13. A valve 0.36 mm. Ophicephalous pedicellaria, exterior view midway between the
ambitus and the abactinal system, from the right anterior inter-
ambulacrum.
14. A valve 0.17 mm. Triphyllous pedicellaria, midway between the actinal system and
the ambitus, from the left anterior interambulacrum.
15. A valve 0.16 mm. Triphyllous pedicellaria, from the same, interior view of a single
valve.
16. A valve 0.34 mm. Ophicephalous pedicellaria, interior view not far from the ocular
plate, from the left posterior ambulacrum.
17. A valve 0.9 mm. Triphyllous pedicellaria, exterior view close to the ocular plate,
of the right posterior ambulacrum.

The enlargement of the pedicellariæ of the actinal system is somewhat greater than that of figs. 7-9 which are drawn on a smaller scale.

All the figures are from a specimen 88 mm. in diameter including the spines. Collected by Dr. Wm. Stimpson at the Bonin Ids.



PLATE 30.

PLATE 30.

1-16. *Colobocentrotus Mertensii* Brandt.

1-16. Valves of pedicellariæ.

1. A valve 0.38 mm. } Ophicephalous pedicellaria, interior view near the teeth.
2. A valve 0.35 mm. } Ophicephalous pedicellaria, exterior view, near the teeth.
3. A valve 0.81 mm. } Tridentate pedicellaria, exterior view, close to the actinal system
from the odd anterior ambulacrum.
4. A valve 0.78 mm. } Tridentate pedicellaria, interior view of the same pedicellaria as 3.
5. A valve 0.77 mm. } Tridentate pedicellaria, profile, interior view of the same as 3.
6. A valve 0.54 mm. } Tridentate pedicellaria, exterior view, midway between the ambitus
and the actinal system, from the left posterior ambulacrum.
7. A valve 0.41 mm. } Tridentate pedicellaria, interior view, from the left posterior am-
bulacrum.
8. A valve 0.47 mm. } Tridentate pedicellaria, close to the ambitus, from the right an-
terior ambulacrum.
9. A valve 0.48 mm. } Ophicephalous pedicellaria, exterior view, close to the ambitus,
from the right anterior ambulacrum.
10. A valve 0.12 mm. } Triphyllous pedicellaria, exterior view, midway between the actinal
system and the ambitus, from the left anterior ambulacrum.
11. A valve 0.14 mm. } Triphyllous pedicellaria, profile, same pedicellaria as 10.
12. A valve 0.46 mm. } Ophicephalous pedicellaria, interior view close to the ambitus,
from the right anterior interambulacrum.
13. A valve 0.44 mm. } Ophicephalous pedicellaria, exterior view of same pedicellaria as
12.
14. A valve 0.31 mm. } Ophicephalous pedicellaria, interior view midway between the am-
bitus and the abactinal system, from the left posterior interam-
bulacrum.
15. A valve 0.27 mm. } Ophicephalous pedicellaria, exterior view of the same pedicellaria
as 14.
16. A valve 0.9 mm. } Triphyllous pedicellaria, exterior view, close to the ocular plate,
from the right anterior ambulacrum.

From a specimen measuring 70 mm. in diameter, with spines.

Bonin Ids., N. P. Ex. Ex., Dr. Wm. Stimpson Coll.



4



PLATE 31.

PLATE 31.

1-4. *Podophora pedifera* Agass.

1-8. Sphæridia.

1. Sphæridia, the first measures 0.27 mm. in length, all from the right posterior ambulacrum.
2. From the odd anterior ambulacrum, the longest measures 0.34 mm., the length of its mate is 0.29 mm.
3. The first figure measures 0.28 mm., the second 0.19 mm., from the left anterior ambulacrum.
4. From the left posterior ambulacrum, the first figure measures 0.26 mm.

5-8. *Podophora atrata* Agass.

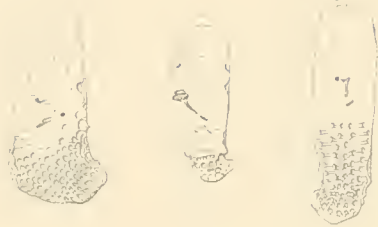
5. Three sphæridia from the right posterior ambulacrum, the middle one measures 0.26 mm.
6. From the odd anterior ambulacrum, the second figure measures 0.25 mm.
7. Sphæridia from the left anterior ambulacrum, the third figure measures 0.26 mm.
8. From the left posterior ambulacrum, the second figure measures 0.29 mm.

The sphæridia of 1-4 are from the same specimen, measuring 85 mm. in diameter, including the spines, and those of 5-8 are from an individual measuring 77 mm.

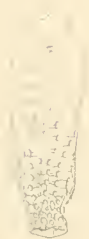
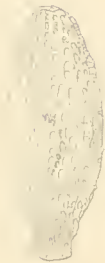
The enlargement of the figures is about the same.



1



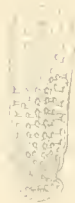
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PLATE 32.

PLATE 32.

1-4. *Colobocentrotus Stimpsoni* A. Ag.

1-8. Sphæridia.

1. Sphæridia, the second measures 0.25 mm. in length; all the sphæridia are from the right posterior ambulacrum.
2. From the odd anterior ambulacrum, the first measures 0.26 mm. in length.
3. The second figure measures 0.27 mm. in length; from the left anterior ambulacrum.
4. From the left posterior ambulacrum, the first figure measures 0.22 mm. in length, the second 0.27 mm.

5-8. *Colobocentrotus Mertensii* Brandt.

5. Three sphæridia from the right posterior ambulacrum, the last one measuring 0.26 mm. in length.
6. From the odd anterior ambulacrum, the first figure measures 0.27 mm. in length and the fourth one 0.23 mm.
7. Sphæridia from the left anterior ambulacrum, the second figure measures 0.25 mm. in length.
8. From the left posterior ambulacrum, the first figure measures 0.28 mm. in length.

The sphæridia of 1-4 are from the same specimen, 88 mm. in diameter, including the spines and those of 5-8 from an individual measuring 70 mm.

The enlargement of the figures is about the same.

Bonin Ids., N. P. Ex. Ex., Dr. Wm. Stimpson Coll.



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PLATE 33.

PLATE 33.

1-3. *Colobocentrotus Stimpsoni* A. Ag.

1. Seen from the actinal side.
2. Seen from the abactinal side.
3. The same specimen, seen in profile, facing the odd anterior ambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figures 1, 2.

All figures are natural size.

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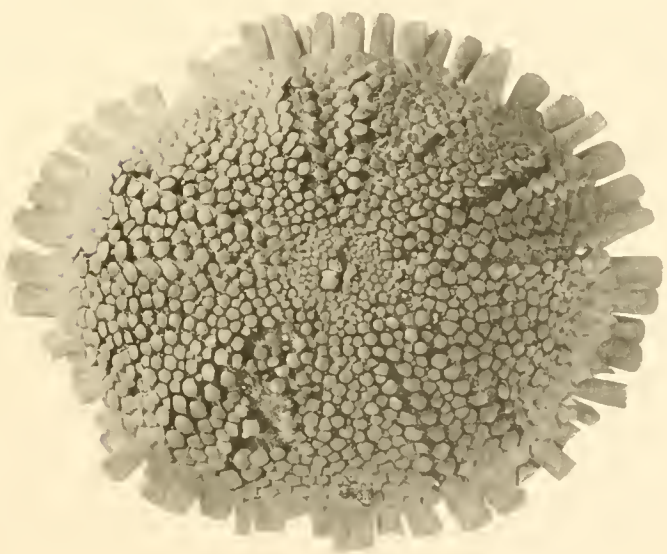
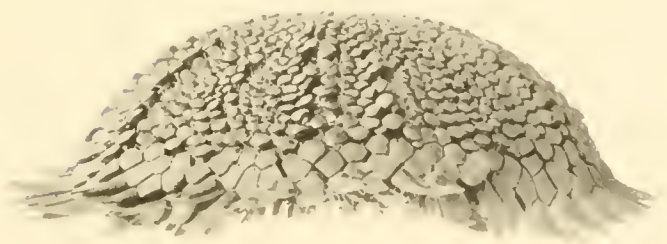
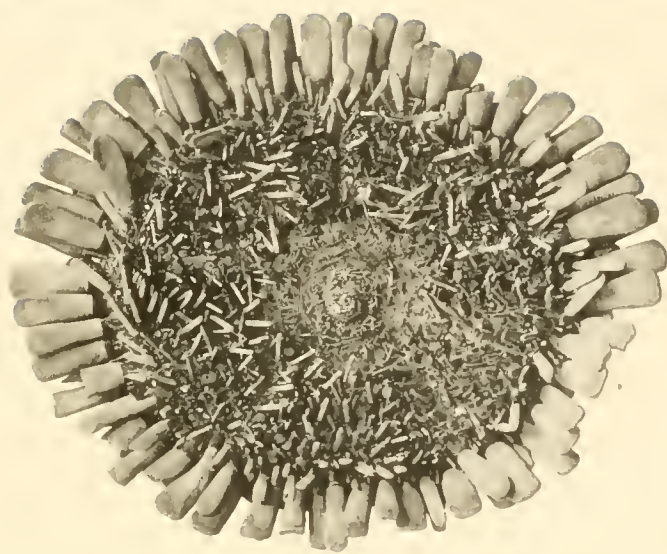


PLATE 34.

PLATE 34.

1-3. *Colobocentrotus Stimpsoni* A. Ag.

1. Seen from the actinal side ; denuded of its spines.
2. The same seen from the abactinal side.
3. The same specimen, seen in profile, facing the odd anterior ambulacrum.

All figures are natural size.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

1

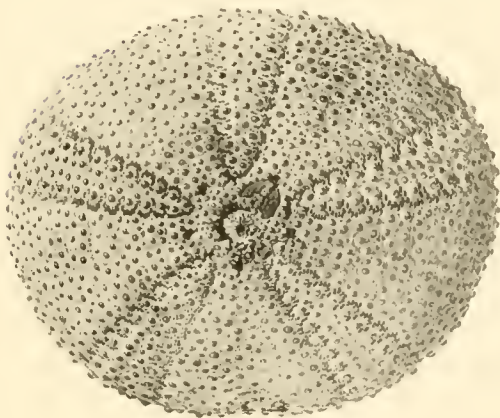
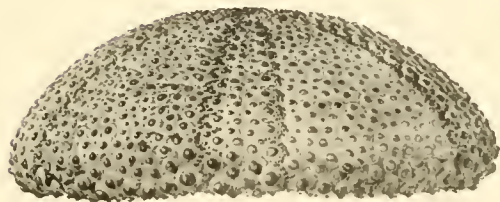
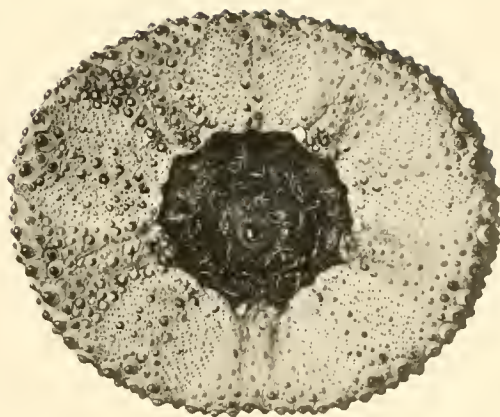


PLATE 35.

PLATE 35.

1-3. *Colobocentrotus Mertensii* Brandt.

1. Seen from the actinal side.
2. Seen from the abactinal side.
3. The same specimen, seen in profile, facing the odd anterior ambulacrum.

All figures are natural size.

The odd anterior ambulacrum occupies the center of the upper part of figs. 1, 2.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

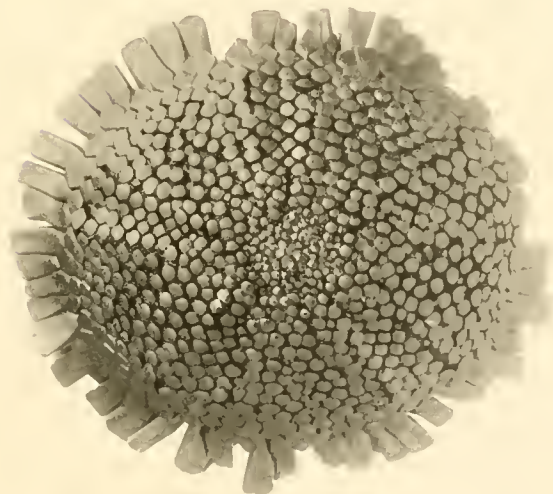
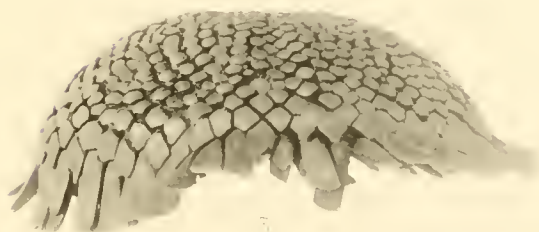


PLATE 36.

PLATE 36.

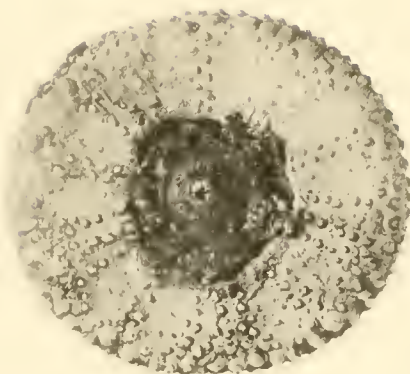
1-3. *Colobocentrotus Mertensii* Brandt.

1. Seen from the actinal side.
2. The same seen from the abactinal side.
3. The same specimen, seen in profile, facing the bivium and odd posterior interambulacrum.

All figures are natural size.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

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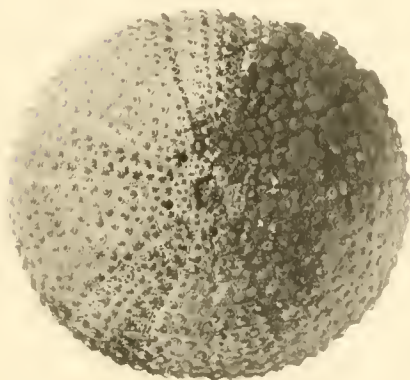


PLATE 37.

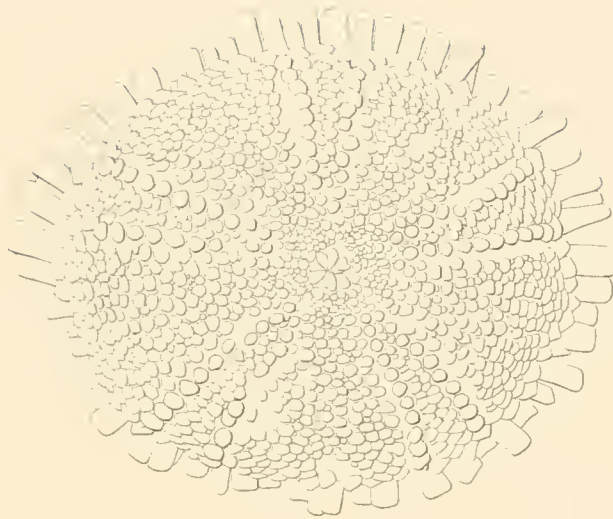
PLATE 37.

1-3. *Colobocentrotus Stimpsoni* A. Ag.

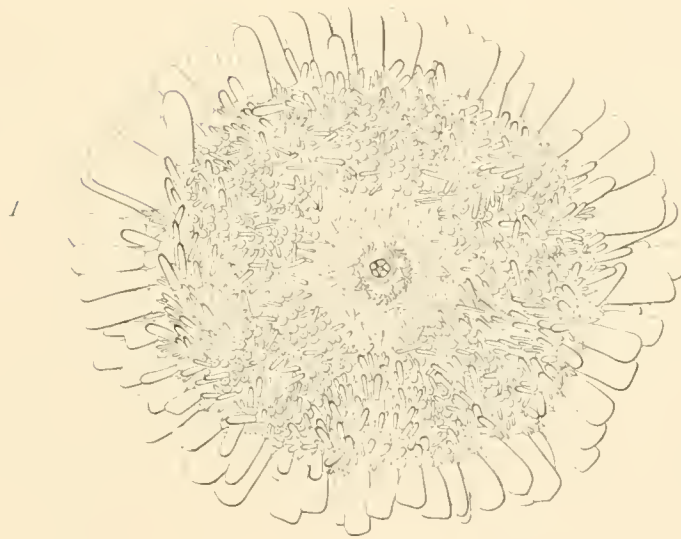
1. Seen from the actinal side, measuring 88 mm. in diameter including the spines.
2. The same seen from the abactinal side.
3. Profile of the same facing the odd anterior ambulacrum.

All figures are natural size.

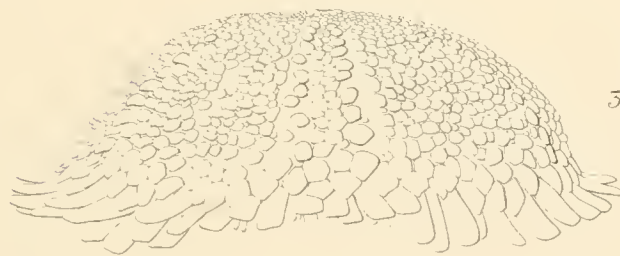
Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.



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PLATE 38.

PLATE 38.

1-3. *Colobocentrotus Stimpsoni* A. Ag.

1. The same as the specimen figured on Plate 37, seen from the actinal side, denuded of its spines, measuring 65 mm. in diameter.
2. The same seen from the abactinal side.
3. Profile of the same, facing the odd anterior ambulacrum.

All figures are natural size.

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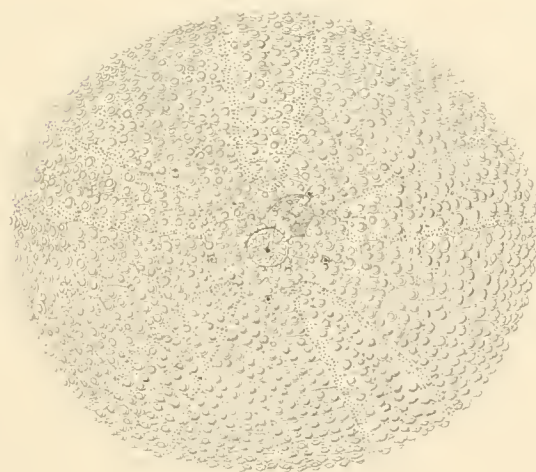
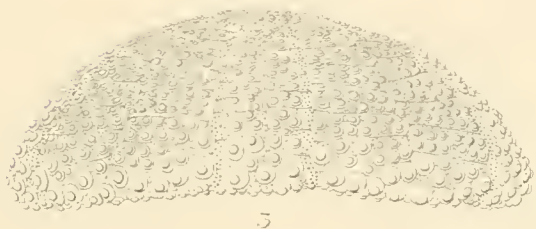
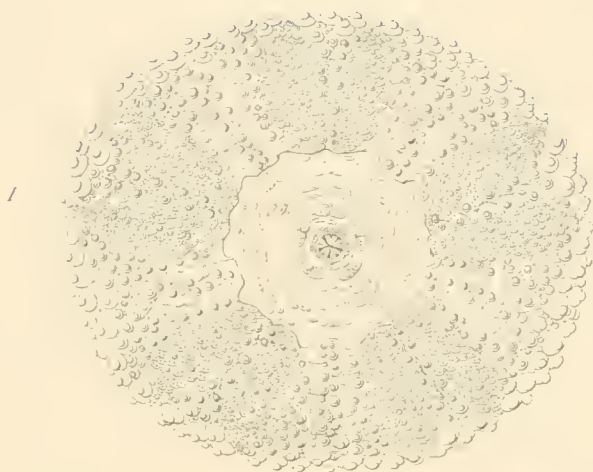


PLATE 39.

PLATE 39.

1-2. *Colobocentrotus Mertensii* Brandt.

1. Showing the right posterior ambulacrum, with the right posterior interambulacrum, and a part of the right anterior ambulacrum.
2. Showing the odd posterior interambulacrum with the bivium, and half of the right posterior ambulacrum.

3-4. *Colobocentrotus Stimpsoni* A. Ag.

3. The right posterior interambulacrum, with the right posterior ambulacrum and a part of the right anterior ambulacrum.
4. The right anterior interambulacrum, with the right anterior ambulacrum and a part of the odd anterior ambulacrum.

1-2 are from a specimen of 70 mm. in diameter, and 3-4 from a specimen measuring 88 mm. in diameter, including the spines. The dotted lines join the radioles of the same vertical row.

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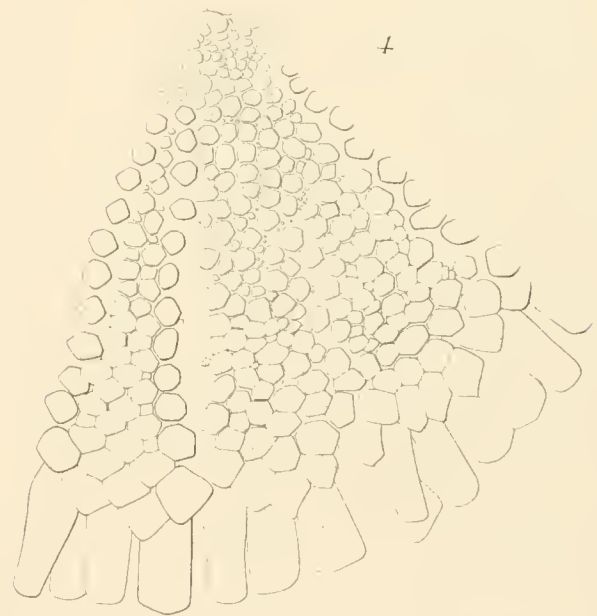
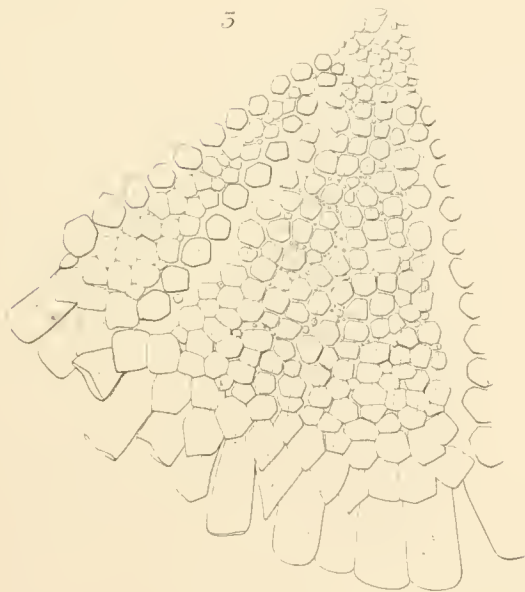
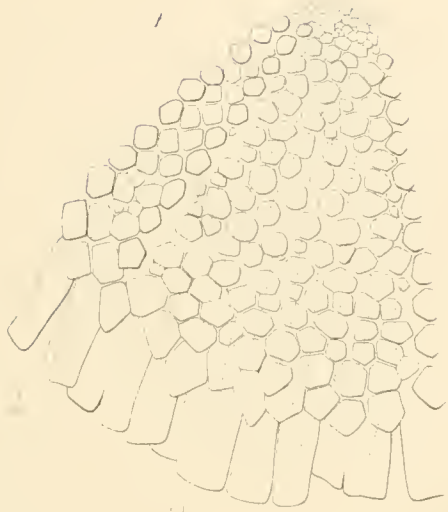


PLATE 40.

PLATE 40

1-32. *Colobocentrotus Stimpsoni* A. Ag.

1-32. Spines.

1. Spine, from the buccal membrane close to the teeth.
2. Spine, from the aetinal system.
3. } Spine, lower side, midway between the aetinal system and the ambitus.
4. } Spine, profile of same as 3.
5. Spine, lower side, from the aetinal side of the ambitus, from the left anterior ambulacrum.
6. } Spine, upper side.
7. } Spine, lower side, from the aetinal side near the ambitus, from the left anterior ambulacrum.
8. } Spine, profile.
9. } Spine, upper side.
10. } Spine, lower side, at the ambitus, from the right posterior ambulacrum. These larger radioles vary in length from 12 to 15 mm.
11. } Spine, profile.
12. } Spine, upper side.
13. } Spine, lower side, from the abaetinal side, near the ambitus, from the left anterior ambulacrum.
14. } Spine, profile.
15. } Spine, upper side.
16. } Spine, lower side, from the abaetinal side near the ambitus, from the left posterior interambulacrum.
17. } Spine, profile.
18. } Spine, top view.
19. } Spine, lower side, midway between the ambitus and the abaetinal system, from the odd anterior ambulacrum.
20. } Spine, profile.
21. } Spine, top view.
22. } Spine, lower side, from the abaetinal side towards the ambitus, from the left posterior ambulacrum.
23. } Spine, profile.
24. } Spine, upper side, from the upper extremity of the left anterior ambulacrum.
25. } Spine, lower side from the upper extremity of the left anterior ambulacrum.
26. } Spine, top view, from the upper extremity of the right posterior interambulacrum.
27. } Spine, lower side from the upper extremity of the right posterior interambulacrum.
28. Miliary spine, near the upper extremity of the right posterior interambulacrum, — hidden by the primary radioles.
29. Miliary spine, lower side, from the anal system.
30. Miliary spine, lower side, from the anal system.
31. } Miliary spine, upper side, from the anal system.
32. } Miliary spine, profile, from the anal system.

The figures are from the same specimen, measuring 88 mm. in diameter.

All the figures are about equally enlarged, except the shaded figures 1, 2, 5, 28, which are considerably enlarged, as is shown by the adjoining outlines.

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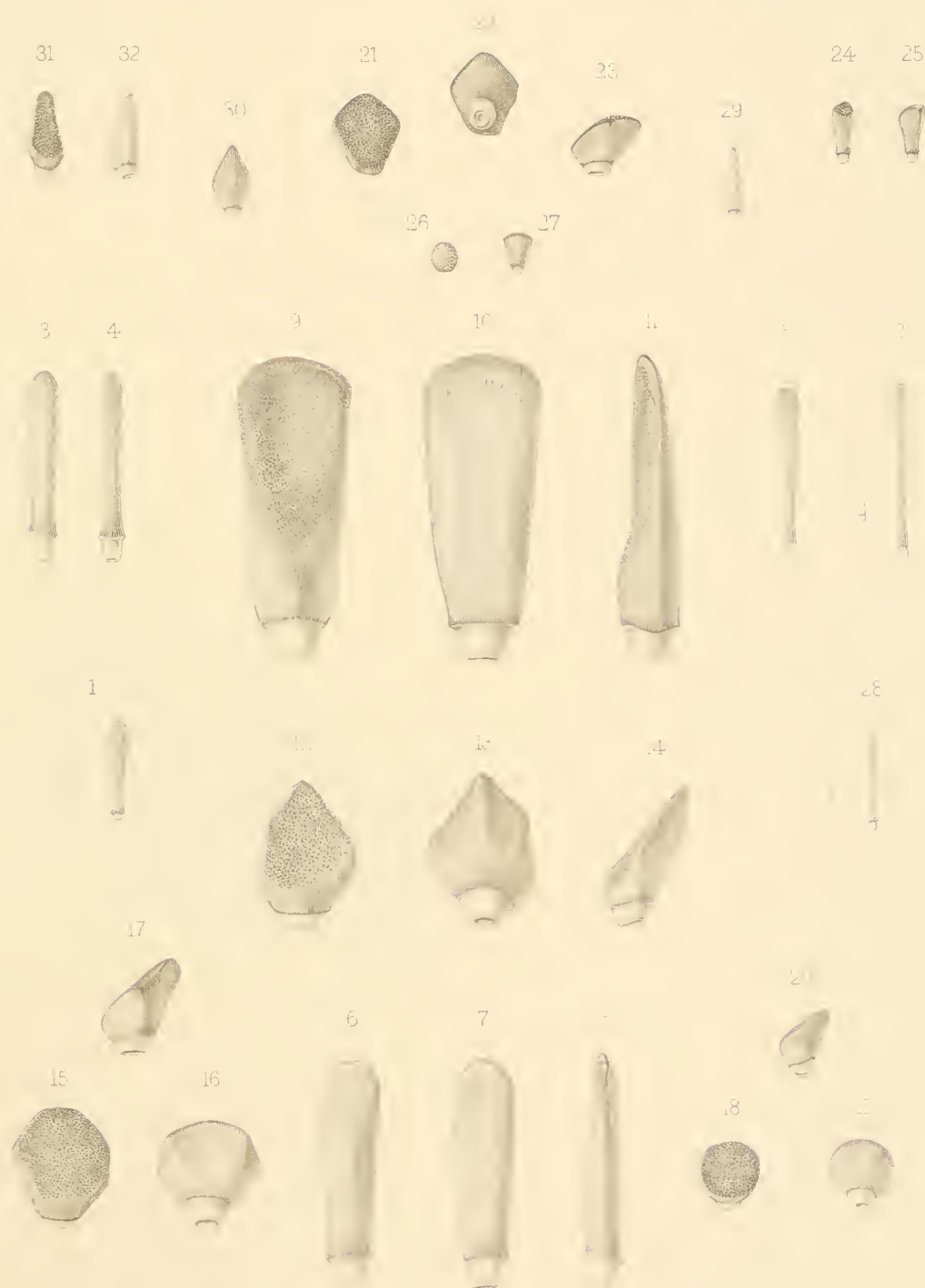


PLATE 41.

PLATE 41.

1-7. *Colobocentrotus Stimpsoni* A. Ag.

1. The left anterior interambulacrum.
2. The ninth and tenth plates from the actinal system of the left anterior interambulacrum.
3. Showing the large tubercle of the fifth plate from the actinal system at the ambitus of the left posterior interambulacrum.
4. The same, seen in profile.
5. One of the primary interambulacral tubercles on the abactinal side.
6. Grouping of the miliaries on the actinal side of the right posterior interambulacrum.
7. Genital plate and pore of the left anterior interambulacrum.

All the figures are from the same specimen, measuring 88 mm. in diameter, including the spines.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.



3



2



4



1



5



6



7

PLATE 42.

PLATE 42.

1-8. *Colobocentrotus Stimpsoni* A. Ag.

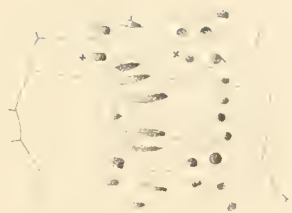
1. Interior view of the actinal side.
2. One of the pairs of perforated plates of the buccal membrane, facing the odd anterior ambulacrum.
3. Exterior view of the odd anterior ambulacral plates adjoining the actinal system.
4. The same seen from the interior of the test.
5. The tenth plate from the actinal system of the odd anterior ambulacrum.
6. The same seen from the interior.
7. Interior view of a plate of the right posterior ambulacrum at the ambitus.
8. The ocular plate and the abactinal extremity of the left posterior ambulacrum, seen from the interior.

In figures 3, 4, and 5, 6, a small cross shows the slanting perforation of the pore through the test.

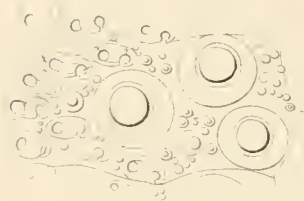
From a specimen measuring 88 mm. in diameter including the spines.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

6



5



8



7



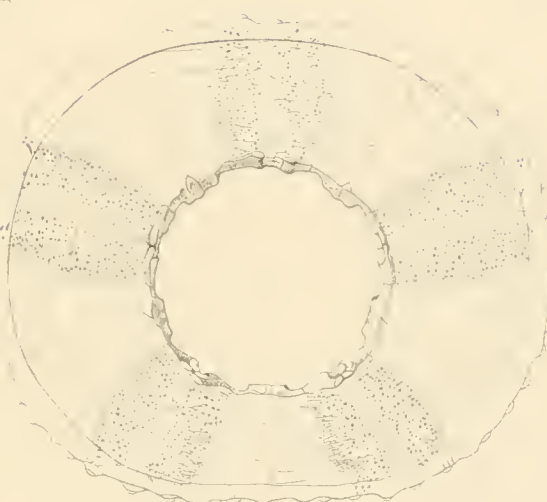
2



3



1



1

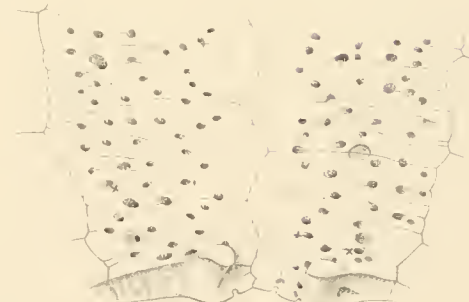


PLATE 43.

PLATE 43.

1-7. *Colobocentrotus Stimpsoni* A. Ag.

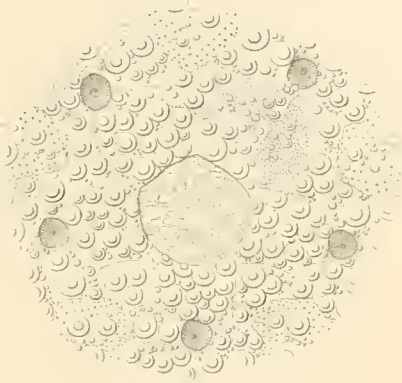
1. The abactinal system, before being denuded of its spines.
2. The abactinal system of the same, denuded.
3. The same, seen from the interior of the test.
4. The auricles of the right posterior ambulacrum, seen from the interior of the test.
5. The auricles as seen looking towards the actinostome through the auricular opening of the left posterior ambulacrum.
6. Plates of the right anterior interambulacrum adjoining the actinal system, seen from the interior of the test.
7. Plates of the odd posterior interambulacrum bordering on the actinal system.

Figs. 6, 7, seem to show the remnant of the ambulacral primordial plates.

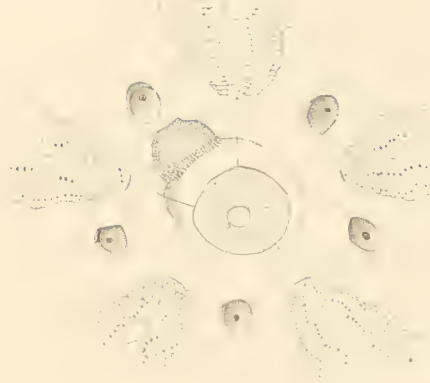
From a specimen measuring 88 mm. in diameter including the spines.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

2



3



1

6



7



1



5

PLATE 44.

PLATE 44.

1-12. *Colobocentrotus Stimpsoni* A. Ag.

1. Lantern seen from above.
2. The same as 1, seen in profile.
3. One of the pyramids, seen from the exterior.
4. The same as 3, seen from the interior.
5. The same, seen in profile.
6. The same, seen from above.
7. a. Epiphysis of pyramid, from the interior, b. pyramid, in profile, from the interior.
8. a. Epiphysis of pyramid, from the exterior, b. pyramid, in profile, from the exterior.
9. Edge of the corrugated surface of pyramid somewhat more enlarged.
10. a. Groove of tooth, b. tooth seen in profile.
11. a. The brace, seen from above, b. seen in profile, c. from below, d. endwise.
12. a. Compass seen in profile, b. seen from above.

All the figures from a denuded specimen 65 mm. in diameter.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

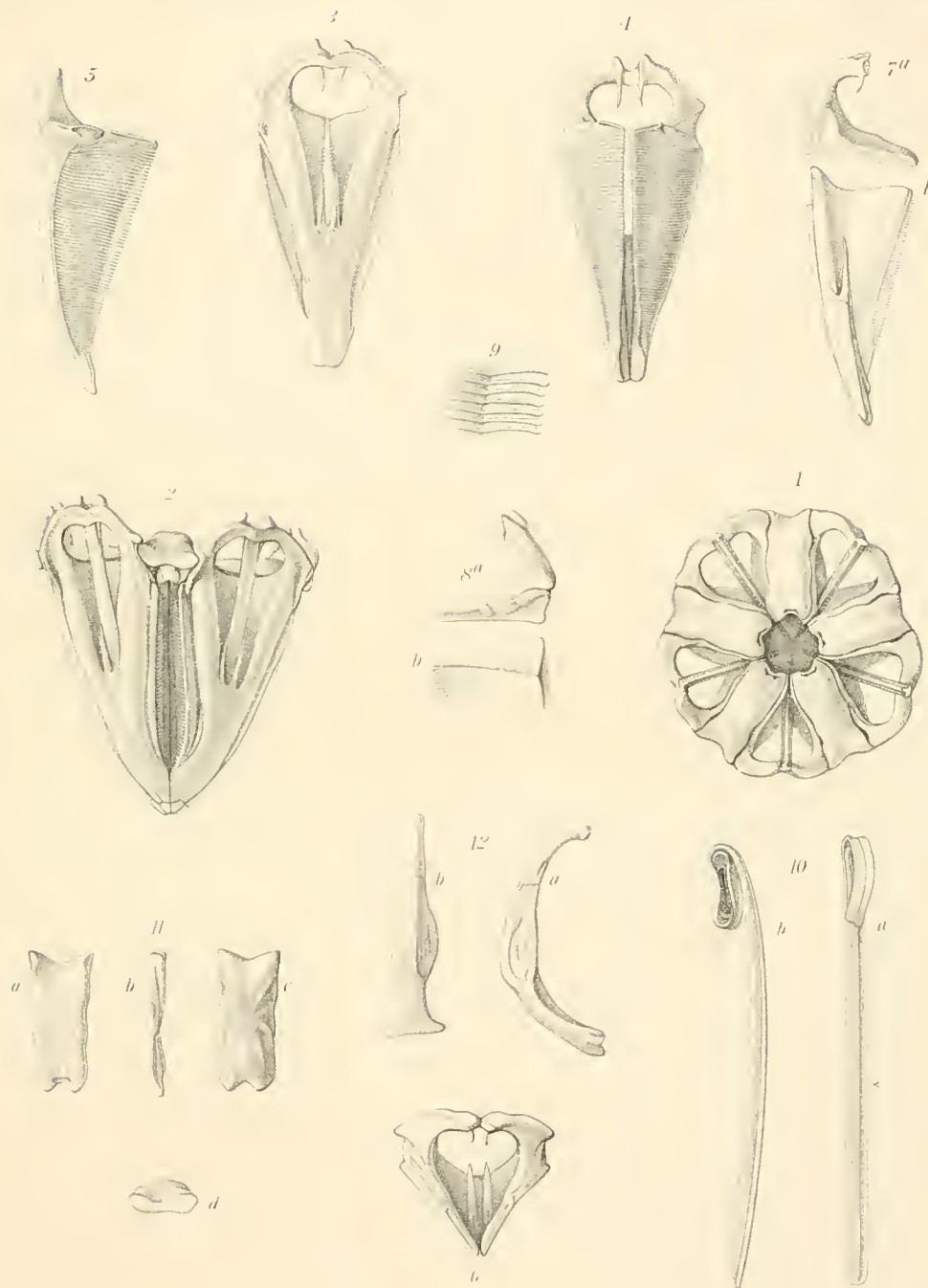


PLATE 45.

PLATE 45.

1-5. *Colobocentrotus Stimpsoni* A. Ag.

1. The disk of an actinal pedicel.
2. The basal part of one of its laminae.
3. Part of a typical spicule.
4. A deformed spicule.
5. Fragment of a deformed spicule.

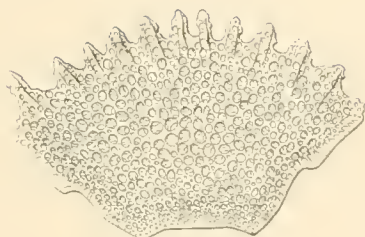
6-10. *Colobocentrotus Mertensii* Brandt.

6. Fragment of a spicule.
7. Basal part of a lamina.
8. Shows the quadratic arrangement of the spicules.
9. Typically formed spicule.
10. Top of a pedicel, taken from the abactinal side and hidden by the large radioles.

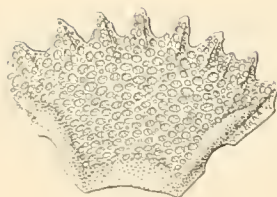
Figures 1-5 are from a specimen, 88 mm. in diameter including the spines and those of 6-10 from an individual, measuring 70 mm. in diameter.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

2



7



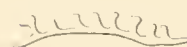
1



5



6



4



5



9



8



10



PLATE 46.

PLATE 46.

1-4. *Podophora pedifera* Agass.

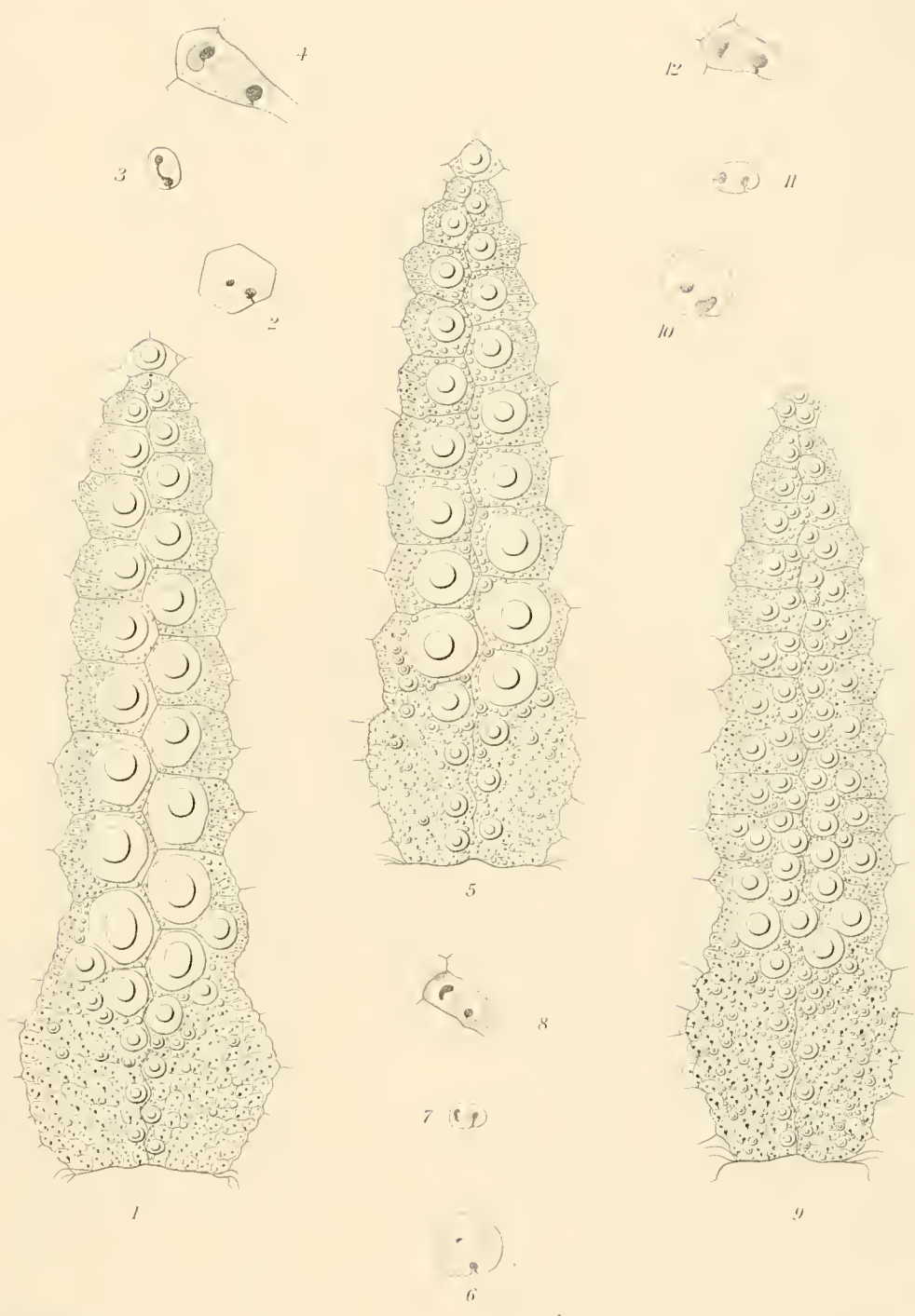
1. The odd anterior ambulacrum of a denuded specimen 55 mm. in diameter.
2. Pore near the actinal system, from the same specimen.
3. Pore at the ambitus.
4. One of the pores of the ninth plate from the actinal system.

5-8. *Podophora atrata* Agass.

5. The odd anterior ambulacrum of a denuded specimen 46 mm. in diameter.
6. Pore near the actinal system, corresponding to the pore of fig. 5.
7. Pore at the ambitus.
8. One of the pores of the eighth plate from the actinal system.

9-12. *Colobocentrotus Stimpsoni* A. Ag.

9. The odd anterior ambulacrum, of a denuded specimen 65 mm. in diameter.
10. Pore near the actinal system corresponding to the pore of fig. 5.
11. Pore at the ambitus.
12. One of the pores of the eleventh plate from the actinal system.



The following Publications of the Museum contain Reports on the Dredging Operations in charge of Alexander Agassiz, of the U. S. Fish Commission Steamer "Albatross," during 1891, Lieut. Commander Z. L. Tanner, U. S. N., Commanding.

- Three Letters from ALEXANDER AGASSIZ to the Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, on the Dredging Operations of the "Albatross" in 1891. Bull. M. C. Z., Vol. XXI. No. 4. June, 1891. 16 pp.
- I. A. AGASSIZ. On Calamocrinus Diomedæ, a new Stalked Crinoid from the Galapagos. Mem. M. C. Z., Vol. XVII. No. 2. January, 1892. 95 pp. 32 Plates.
- II. A. AGASSIZ. General Sketch of the Expedition of the "Albatross," from February to May, 1891. Bull. M. C. Z., Vol. XXIII. No. 1. February, 1892. 89 pp. 22 Plates.
- III. A. GOËS. Neusina Agassizi. Bull. M. C. Z., Vol. XXIII. No. 5. December, 1892. 4 pp. 1 Plate.
- IV. H. LUDWIG. Vorläufiger Bericht über die erbeuteten Holothurien. Zeit. Anz., No. 420. 1893. Bull. M. C. Z., Vol. XXIV. No. 4. June, 1893. 10 pp.
- V. GEO. P. MERRILL. The Rocks of the Galapagos. Bull. M. C. Z., Vol. XVI. No. 13. July, 1893. 3 pp.
- VI. W. FAXON. Preliminary Descriptions of new Species of Crustacea. Bull. M. C. Z., Vol. XXIV. No. 7. August, 1893. 72 pp.
- VII. S. H. SCUDDER. The Orthoptera of the Galapagos. Bull. M. C. Z., Vol. XXV. No. 1. September, 1893. 25 pp. 3 Plates.
- VIII. W. SCHIMKÉWITSCH. The Pynogonidæ. Bull. M. C. Z., Vol. XXV. No. 2. December, 1893. 17 pp. 2 Plates.
- IX. W. McM. WOODWORTH. The Planarians. Bull. M. C. Z., Vol. XXV. No. 4. January, 1894. 4 pp. 1 Plate.
- X. TH. STUDER. Note préliminaire sur les Aleyonaires. Bull. M. C. Z., Vol. XXV. No. 5. February, 1894. 17 pp.
- XI. S. F. CLARKE. The Hydroids. Bull. M. C. Z., Vol. XXV. No. 6. February, 1894. 7 pp. 5 Plates.
- XII. H. LUDWIG. The Holothurians. Mem. M. C. Z., Vol. XVII. No. 3. October 1894. 183 pp. 19 Plates.
- XIII. R. BERGH. Die Opisthobranchien. Bull. M. C. Z., Vol. XXV. No. 10. October, 1894. 109 pp. 12 Plates.
- XIV. A. ORTMANN. The Pelagic Schizopoda. Bull. M. C. Z., Vol. XXV. No. 8. September, 1894. 13 pp. 1 Plate.
- XV. W. FAXON. The Crustacea. Mem. M. C. Z., Vol. XVIII. April, 1895. 292 pp. 67 Plates.
- XVI. W. GIESBRECHT. Die Pelagischen Copepoden. Bull. M. C. Z., Vol. XXV. No. 12. April, 1895. 20 pp. 4 Plates.
- XVII. C. H. TOWNSEND. The Birds of Cocos Island. Bull. M. C. Z., Vol. XXVII. No. 3. July, 1895. 8 pp. 2 Plates.
- XVIII. C. HARTLAUB. Die Comatuliden. Bull. M. C. Z., Vol. XXVII. No. 4. August, 1895. 26 pp. 4 Plates.
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- XX. A. GOËS. The Foraminifera. Bull. M. C. Z., Vol. XXIX. No. 1. February, 1896. 103 pp. 9 Plates.
- XXI. O. MAAS. Die Medusen. Mem. M. C. Z., Vol. XXIII. No. 1. September, 1897. 92 pp. 15 Plates.
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- XXV. C. F. LÜTKEN and TH. MORTENSEN. The Ophiuridæ. Mem. M. C. Z., Vol. XXIII. No. 2. November, 1899. 114 pp. 22 Plates and Chart.
- XXVI. S. GARMAN. The Fishes. Mem. M. C. Z., Vol. XXIV. November, 1899. 426 pp. 97 Plates and Chart.
- XXVII. W. McM. WOODWORTH. Preliminary Account of Planktonemertes Agassizii. Bull. M. C. Z., Vol. XXXV. No. 1. July, 1899. 4 pp. 1 Plate.
- XXVIII. L. STEJNEGER. Two new Lizards of the genus Anolis, from Cocos and Malpelo Islands. Bull. M. C. Z., Vol. XXXVI. No. 6. November, 1900. 6 pp. 1 Plate.
- XXIX. W. E. HOYLE. The Cephalopoda. Bull. M. C. Z., Vol. XLIII. No. 1. March, 1904. 71 pp. 12 Plates.
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- XXXII. A. AGASSIZ. The Panamic Deep Sea Echini. Mem. M. C. Z., Vol. XXXI. November, 1904. 10, 243 pp. 112 Plates.
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- XXXIV. E. VON MARENZELLER. Lagisca Irritans, sp. nov., ein Symbiont von Hydrokorallen. Bull. M. C. Z., Vol. XLIII. No. 3. August, 1904. 6 pp. 1 Plate.
- XXXV. H. LUDWIG. Asteroidea. Mem. M. C. Z., Vol. XXXII. July, 1905. 12, 292 pp. 35 Plates, 1 Chart.
- XXXVI. E. TROJAN. Ein Beitrag zur Morphologie des Tiefseefischgehirnes. Mem. M. C. Z., Vol. XXX. No. 3. October, 1906. 42 pp. 6 Plates.
- XXXVII. W. H. DALL. The Mollusca and the Brachiopoda. Bull. M. C. Z., Vol. XLIII. No. 6. October, 1908. 286 pp. 22 Plates.

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